Appendix K

APPENDIX K

PUMP, PIPE, AND SUMP SIZING CALCULATIONS

APPENDIX K1

LEAK DETECTION AND LEACHATE COLLECTION SUMP HYDRAULIC ANALYSIS

U.S. STEEL – GARY WORKS

CAMU LANDFILL

LEACHATE COLLECTION & DETECTION SYSTEM

HYDRAULIC ANALYSIS

Prepared by

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August 20, 2001

earth tech engineering and technology for the planet.

August 20, 2001

Based on the Montgomery / Watson assumptions Sheet 3 of 4 and 4 of 4 dated 10/6/00, the following analysis is presented:

Unit 1

Leachate Collection – Sump Collection, Fill Rate

337 gal / 1.11 gpm = 303.6 min. = 5.1 hrs

Leachate Detection – Sump Collection, Fill Rate

606 gal. / 0.066 gpm = 9181.8 min. = 153.0 hrs.

Unit 2 (1)

Leachate Collection – Sump Collection, Fill Rate

505 gal / (2.91 x 2/3) = 260 min. = 4.3 hrs.

Leachate Collection – Sump Collection, Fill Rate

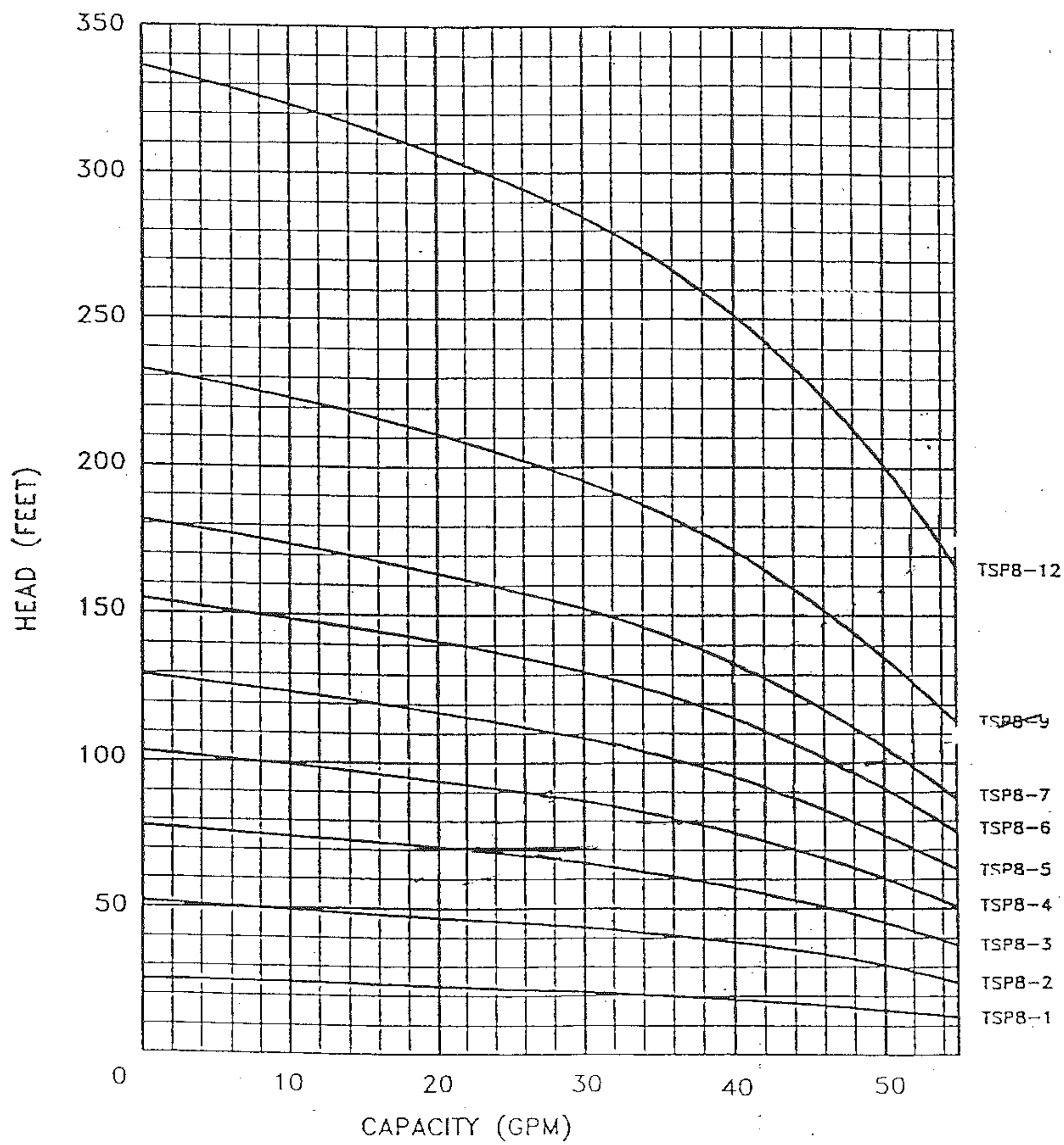
555.5 gal / (0.40 x 2/3) = 2083 min. = 34.7 hrs.

(1) Original M/W design included two (2) sumps. The unit as currently designed has been adjusted for the placement of three (3) sumps.

The following scenarios (next page) are presented for review. These analyses present the extreme cases of the hydraulic network for each unit of the Camu Landfill. Other such iterations of this work will typically lie in between the results as presented.

Camu Landfill Unit	File Name	Pump I.D.	Element No.	EPG Pump Model	HP	Q (gpm)	Est. Draw Down Rate (min.)	Comments
1	CAMU_4	CM1-1 LD	1	TSP8-3	3	19.14	32	Unit 1 with all four sump pumps on.
		CM1-2 LD	17	TSP8-3	3	11.88	51	
		CM1-1 LC	19	TSP8-3	3	25.18	14	
		CM1-2 LC	35	TSP8-3	3	32.27	11	
					Total	88.47		
1	CAMU_2LC	CM1-1 LC	19	TSP8-3	3	35.78	9.4	Unit 1 with both collection sump pumps on.
		CM1-2 LC	35	TSP8-3	3	40.35	8.3	
					Total	76.13		
1	CAMU_2LD	CM1-1 LD	1	TSP8-3	3	36.03	17	Unit 1 with both detection sump pumps on
		CM1-2LD	17	TSP8-3	3	35.24	17	
					Total	71.27		
2	CAMU2_3D	CM2-1 LD	1	TSP8-2	2	26.23	22	Unit 2 with all three detection sump pumps on.
		CM2-2 LD	20	TSP8-2	2	33.14	17	
		CM2-3 LD	22	TSP8-2	2	41.64	14	
					Total	101.01		
2	CAMU2_3L	CM2-1 LC	1	TSP8-2	2	28.05	18	Unit 2 with all three collection sump pumps on.
		CM2-2 LC	20	TSP8-2	2	35.04	14	
		CM2-3 LC	22	TSP8-2	2	43.67	12	
					Total	106.76		
2	CAMU2_1D	CM2-1 LD	1	TSP8-2	2	32.19	17	Unit 2 with one detection sump pump on
					Total	32.19		
2	CAMU2_1L	CM2-1 LC	1	TSP8-2	2	34.36	15	Unit 2 with one collection sump pump on.
					Total	34.36		

TSP8 PERFORMANCE CURVES



U.S. STEEL – GARY WORKS

CAMU LANDFILL

UNIT No. 1

LEACHATE COLLECTION
& DETECTION SYSTEM

HYDRAULIC ANALYSIS

Prepared by

Earth Tech
3121 Butterfield Rd.
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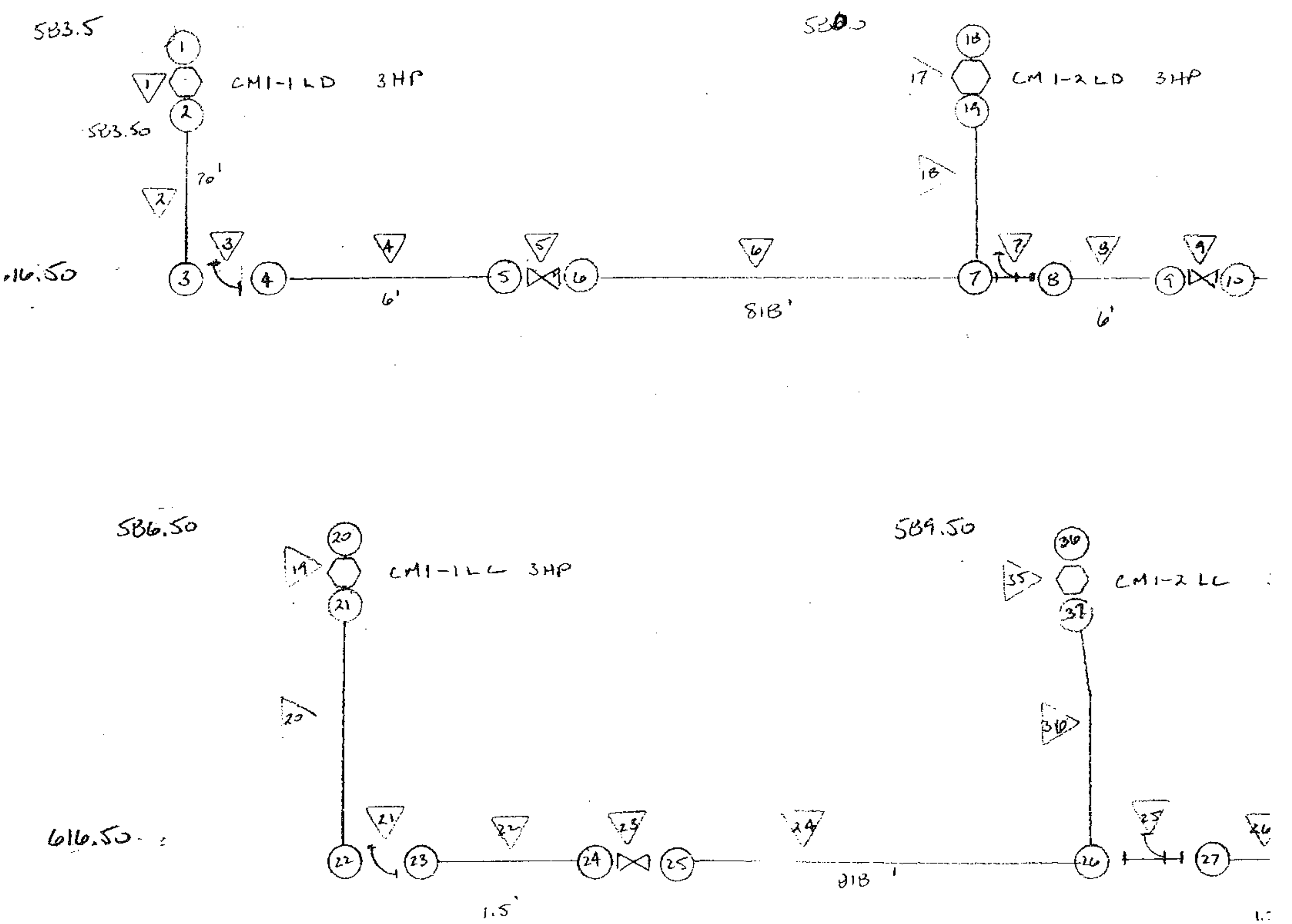
(630) 574-2006

August 20, 2001

Unit 1 USS Camu 8/19/01



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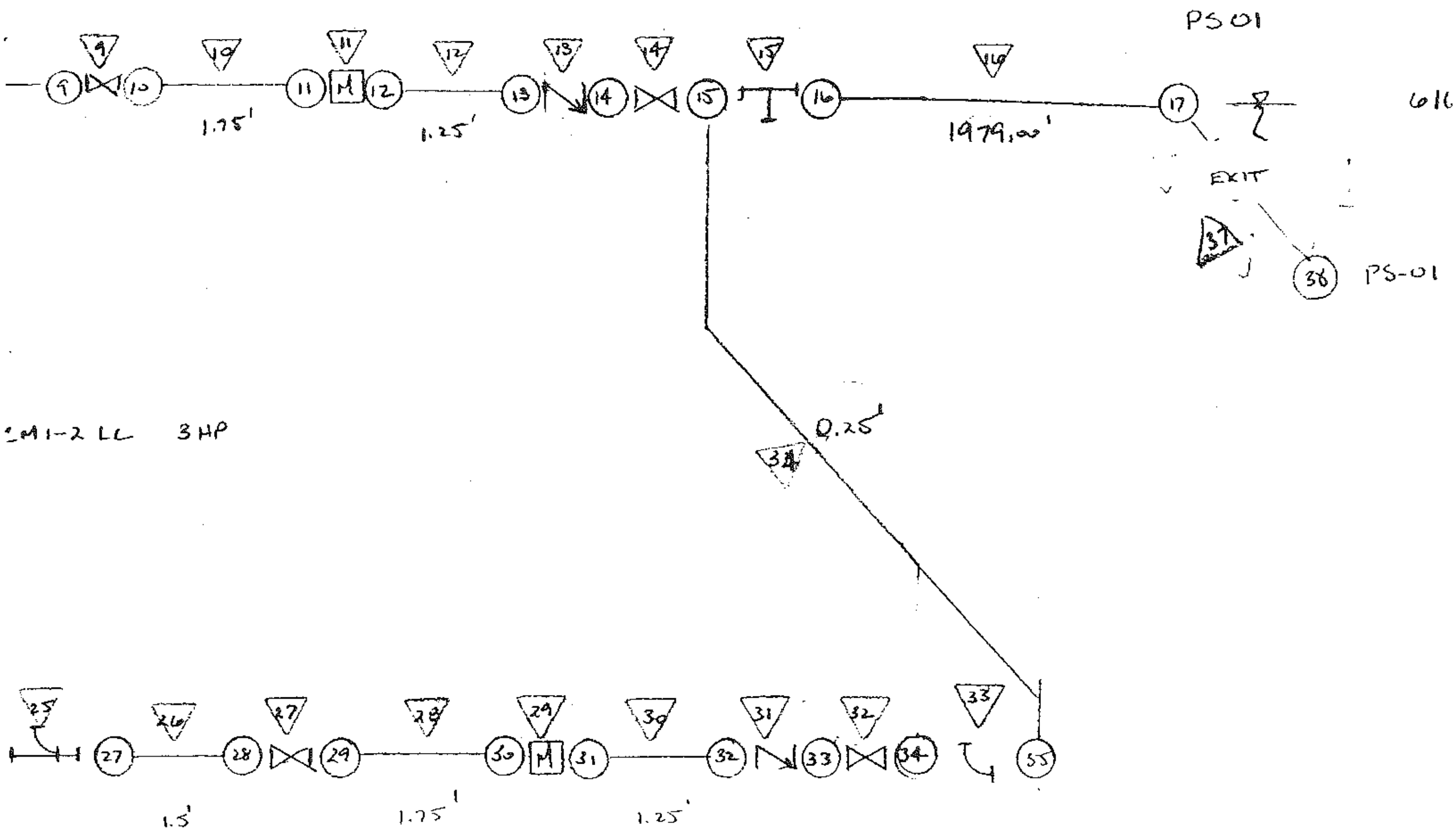


SUMMARY OF SYSTEM DATA
(Balanced system data for CAMU_2LC.NET)

PIPE HEAD LOSS EQUATION: Hazen-Williams Eq.
Tolerance for solution = 0.0100000 gpm

FLUID PROPERTIES: Specific Gravity = 1.000

ELEMENT AND NODE SUMMARY:

Total pipes	=	9	Total Nodes	=	22
Total valves & fittings	=	10			
Total Pumps (or FVH's)	=	2	Total Loops	=	2
Total Elements	=	21	Total Branches	=	0

PIPES:

El#	Length (feet)	Friction	Diameter (inches)	Flow (gpm)	Direction Node->Node	Velocity (ft/s)	Head Loss (feet)
	1979.00 UNIT 1 FM	150	3.000	76.13	16-> 17	3.46	28.13
20	65.00 CM1-1 LC 2" PUMP DISCHARGE	140	2.000	35.78	21-> 22	3.65	1.87
22	1.50 CM1-1 LC	150	3.000	35.78	23-> 24	1.62	0.01
24	818.00 CM1-1 LC	150	3.000	35.78	25-> 26	1.62	2.88
26	1.50 CM1-2 LC	150	3.000	76.13	27-> 28	3.46	0.02
28	1.75 CM1-2 LC	150	3.000	76.13	29-> 30	3.46	0.02
30	1.25 CM1-2 LC	150	3.000	76.13	31-> 32	3.46	0.02
34	0.25 CM1-2 LC	150	3.000	76.13	35-> 15	3.46	0.00
36	75.00 CM1-2 LC	140	2.000	40.35	37-> 26	4.12	2.69

VALVES & FITTINGS:

El#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
15	Standard Tee-thru branch UNIT 1 FM	1.08	3.000	76.13	15-> 16	0.20
. _	Standard elbow-90 degree CM1-1 LC	0.54	3.000	35.78	22-> 23	0.02

'ALVES & FITTINGS: cont'd...

l#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
23	Gate valve CM1-1 LC	0.14	3.000	35.78	24-> 25	0.01
25	Standard Tee-thru branch CM1-2 LC	1.08	3.000	76.13	26-> 27	0.20
27	Gate valve CM1-2 LC	0.14	3.000	76.13	28-> 29	0.03
29	Standard Tee-thru flo CM1-2 LC METER	0.36	3.000	76.13	30-> 31	0.07
31	Swing check-valve (L/D = 50) CM1-2 LC	0.90	3.000	76.13	32-> 33	0.17
32	Gate valve CM1-2 LC	0.14	3.000	76.13	33-> 34	0.03
33	Standard elbow-90 degree CM1-2 LC	0.54	3.000	76.13	34-> 35	0.10
37	Exit DISCHARGE TO PS-01	1.00	3.000	76.13	17-> 38	0.19

'UMPS (FVHs):

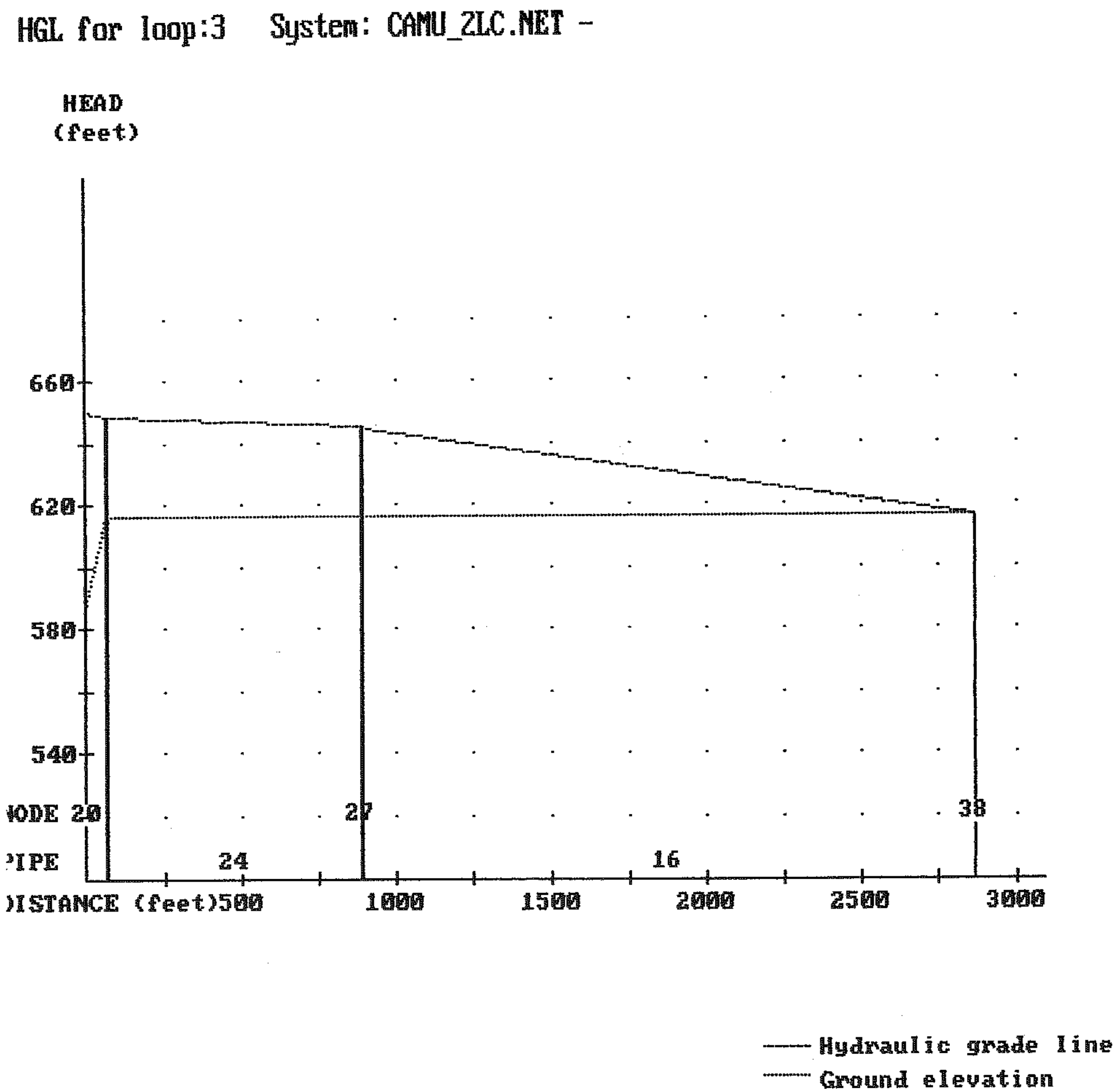
l#	Flow inc (gpm)	Shut hd (feet)	2nd (feet)	3rd (feet)	4th (feet)	Flow (gpm)	Direction Node->Node	Operating Head (feet)
19	16.00	78	72	66	45	35.78	20-> 21	62.95 feet
CM1-1 LC PUMP- Suction node #20, head = 1.00 feet								
35	16.00	78	72	66	45	40.35	36-> 37	57.86 feet
CM1-2 LC- Suction node #36, head = 1.00 feet								

IODES:

Iode#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
15	616.50 UNIT 1 FM	N/A	N/A	0.00	28.51	645.01
16	616.50 UNIT 1 FM	N/A	N/A	0.00	28.31	644.81
17	616.50 DISCHARGE TO PS-01	N/A	N/A	0.00	0.19	616.69
20	586.50 CM1-1 LC	N/A	N/A	35.78	1.00	587.50 fh
21	586.50 CM1-1 LC	N/A	N/A	0.00	63.95	650.45
22	616.50 CM1-1 LC	N/A	N/A	0.00	32.08	648.58
23	616.50 CM1-1 LC	N/A	N/A	0.00	32.06	648.56
24	616.50 CM1-1 LC	N/A	N/A	0.00	32.05	648.55

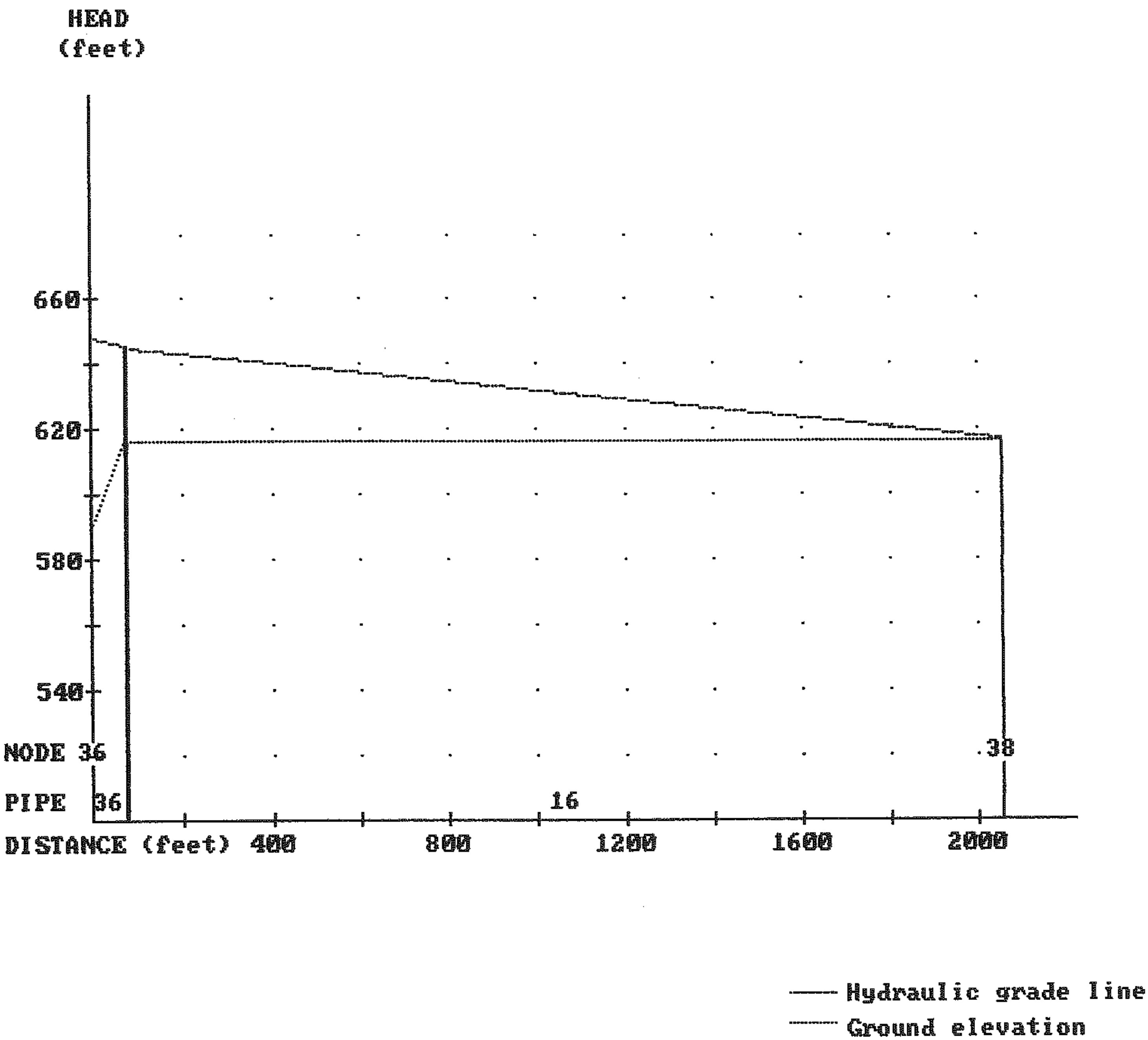
NODES: cont'd...

Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
25	616.50 CM1-1 LC	N/A	N/A	0.00	32.05	648.55
26	616.50 JUNCTION W/ CM1-2 LC	N/A	N/A	0.00	29.17	645.67
27	616.50 CM1-2 LC	N/A	N/A	0.00	28.97	645.47
28	616.50 CM1-2 LC	N/A	N/A	0.00	28.95	645.45
29	616.50 CM1-2 LC	N/A	N/A	0.00	28.92	645.42
30	616.50 CM1-2 LC	N/A	N/A	0.00	28.90	645.40
31	616.50 CM1-2 LC	N/A	N/A	0.00	28.83	645.33
32	616.50 CM1-2 LC	N/A	N/A	0.00	28.81	645.31
33	616.50 CM1-2 LC	N/A	N/A	0.00	28.64	645.14
34	616.50 CM1-2 LC	N/A	N/A	0.00	28.62	645.12
35	616.50 CM1-2 LC	N/A	N/A	0.00	28.52	645.02
36	589.50 CM1-2 LC	N/A	N/A	40.35	1.00	590.50 fh
37	589.50 CM1-2 LC	N/A	N/A	0.00	58.86	648.36
38	616.50 PS-01	N/A	N/A	-76.13	0.00	616.50 fh

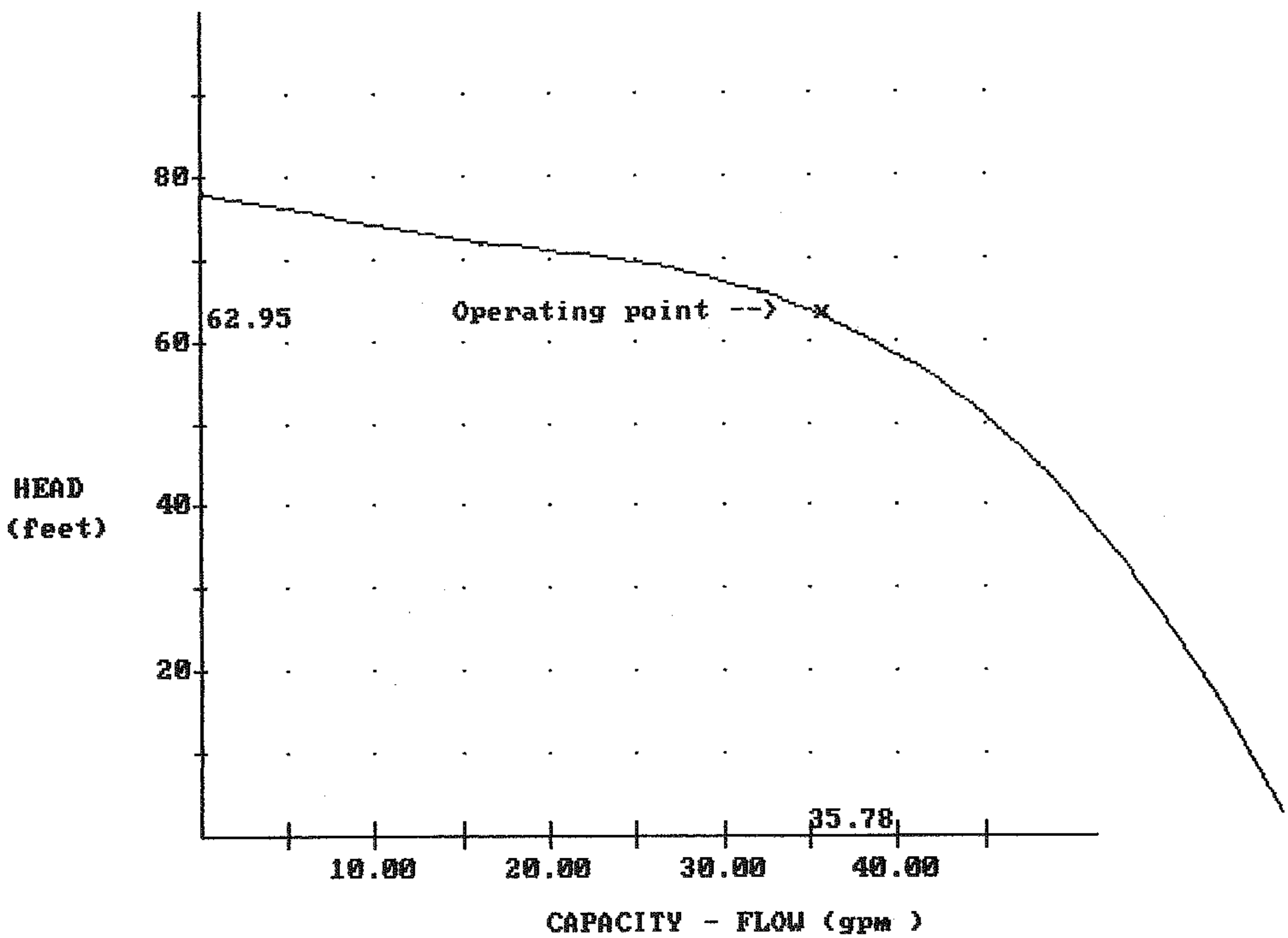


HGL for loop:3 System: CAMU_ZLC.NET -
HEAD
(feet)
660
620
580
540
NODE 20
27
38
PIPE
24
16
DISTANCE (feet)500
1000
1500
2000
2500
3000
Hydraulic grade line
Ground elevation

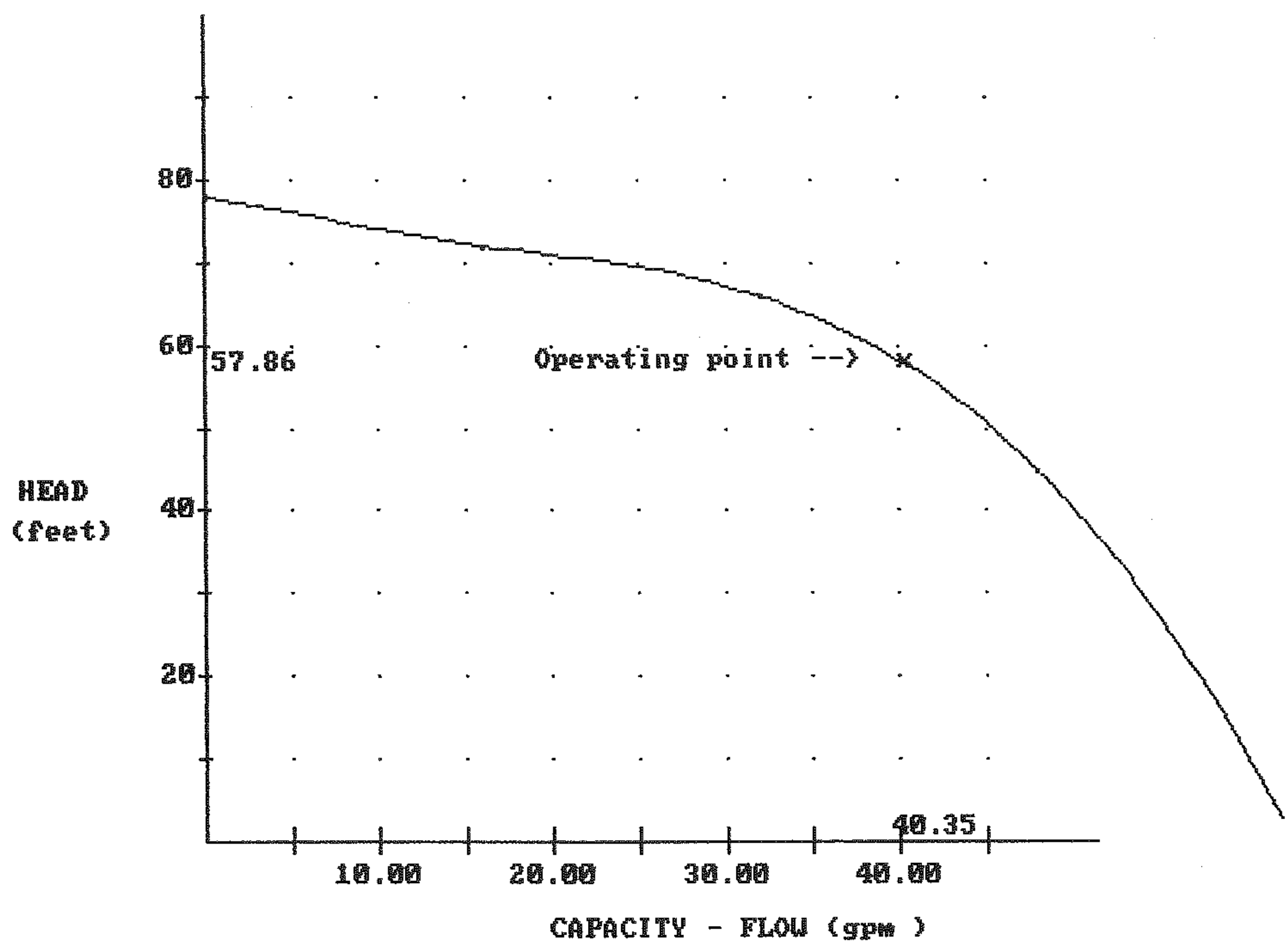
HGL for loop:4 System: CAMU_ZLC.NET -



PUMP #19 System: CAMU_ZLC.NET -



PUMP #35 System: CAMU_2LC.NET -



P e 1
Da : 8/21/101 2:14 pm

SUMMARY OF SYSTEM DATA
(Balanced system data for CAMU_2LD.NET)

PIPE HEAD LOSS EQUATION: Hazen-Williams Eq.
Tolerance for solution = 0.0100000 gpm

FLUID PROPERTIES: Specific Gravity = 1.000

ELEMENT AND NODE SUMMARY:

Total pipes	= 8	Total Nodes	=	20
Total valves & fittings	= 9			
Total Pumps (or FVH's)	= 2	Total Loops	=	2
Total Elements	= 19	Total Branches	=	0

PIPES:

El#	Length (feet)	Friction	Diameter (inches)	Flow (gpm)	Direction Node->Node	Velocity (ft/s)	Head Loss (feet)
	70.00	140	2.000	36.03	2-> 3	3.68	2.04
	FM CM1-1LD 2" PUMP HOSE						
4	6.00	150	3.000	36.03	4-> 5	1.64	0.02
	CM1-1 LD						
6	818.00	150	3.000	36.03	6-> 7	1.64	2.91
	CM1-1 LD FM						
8	6.00	150	3.000	71.27	8-> 9	3.23	0.08
	CM1-2 LD						
10	1.75	150	3.000	71.27	10-> 11	3.23	0.02
	CM1-2 LD						
12	1.25	150	3.000	71.27	12-> 13	3.23	0.02
	CM1-2 LD						
16	1979.00	150	3.000	71.27	16-> 17	3.23	24.89
	UNIT 1 FM						
18	80.00	140	2.000	35.24	19-> 7	3.60	2.23
	CM2-1 PUMP DISCHARGE HOSE 2"						

VALVES & FITTINGS:

El#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
3	Standard elbow-90 degree	0.54	3.000	36.03	3-> 4	0.02
	CM1-1 LD					
5	Gate valve	0.14	3.000	36.03	5-> 6	0.01
	CM1-1 LD					
	Standard Tee-thru branch	1.08	3.000	71.27	7-> 8	0.18
	CM1-2 LD					

VALVES & FITTINGS: cont'd...

El#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
9	Gate valve CM1-2 LD	0.14	3.000	71.27	9-> 10	0.02
11	Enlarge/Contract(Angle= 90.00) CM1-2 LD METER	0.00		71.27	11-> 12	0.00
13	Swing check-valve (L/D = 50) CM1-2 LD	0.90	3.000	71.27	13-> 14	0.15
14	Gate valve CM1-2 LD	0.14	3.000	71.27	14-> 15	0.02
15	Standard Tee-thru branch UNIT 1 FM	1.08	3.000	71.27	15-> 16	0.18
37	Exit DISCHARGE TO PS-01	1.00	3.000	71.27	17-> 38	0.16

PUMPS (FVHs):

El#	Flow inc (gpm)	Shut hd (feet)	2nd (feet)	3rd (feet)	4th (feet)	Flow (gpm)	Direction Node->Node	Operating Head (feet)
1	16.00	78	72	66	45	36.03	1-> 2	62.71 feet
CM1-1 LD- Suction node #1, head = 1.00 feet								
17	16.00	78	72	66	45	35.24	18-> 19	63.45 feet
CM1-2 LD PUMP- Suction node #18, head = 1.00 feet								

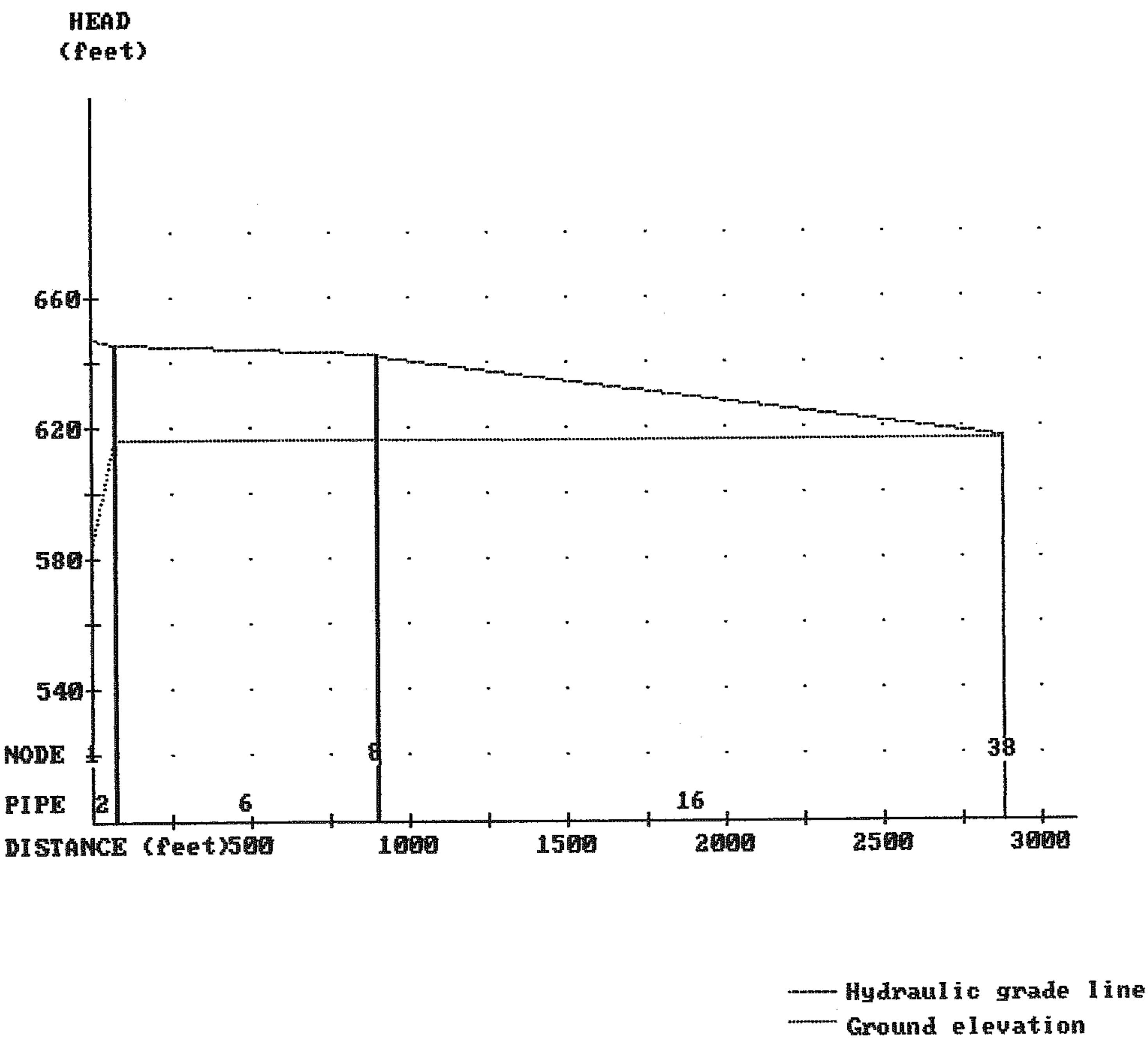
NODES:

Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
1	583.50 CM1-1 LD	N/A	N/A	36.03	1.00	584.50 fh
2	583.50	N/A	N/A	0.00	63.71	647.21
3	616.50 CM1-1	N/A	N/A	0.00	28.68	645.18
4	616.50 CM1-1 LD	N/A	N/A	0.00	28.65	645.15
5	616.50 CM1-1 LD	N/A	N/A	0.00	28.63	645.13
6	616.50 CM1-1 LD	N/A	N/A	0.00	28.63	645.13
7	616.50 CM1-2	N/A	N/A	0.00	25.71	642.21
8	616.50 CM1-2 LD	N/A	N/A	0.00	25.54	642.04
9	616.50 CM1-2	N/A	N/A	0.00	25.46	641.96
10	616.50 CM1-2 LD	N/A	N/A	0.00	25.44	641.94
11	616.50 CM1-2 LD	N/A	N/A	0.00	25.42	641.92

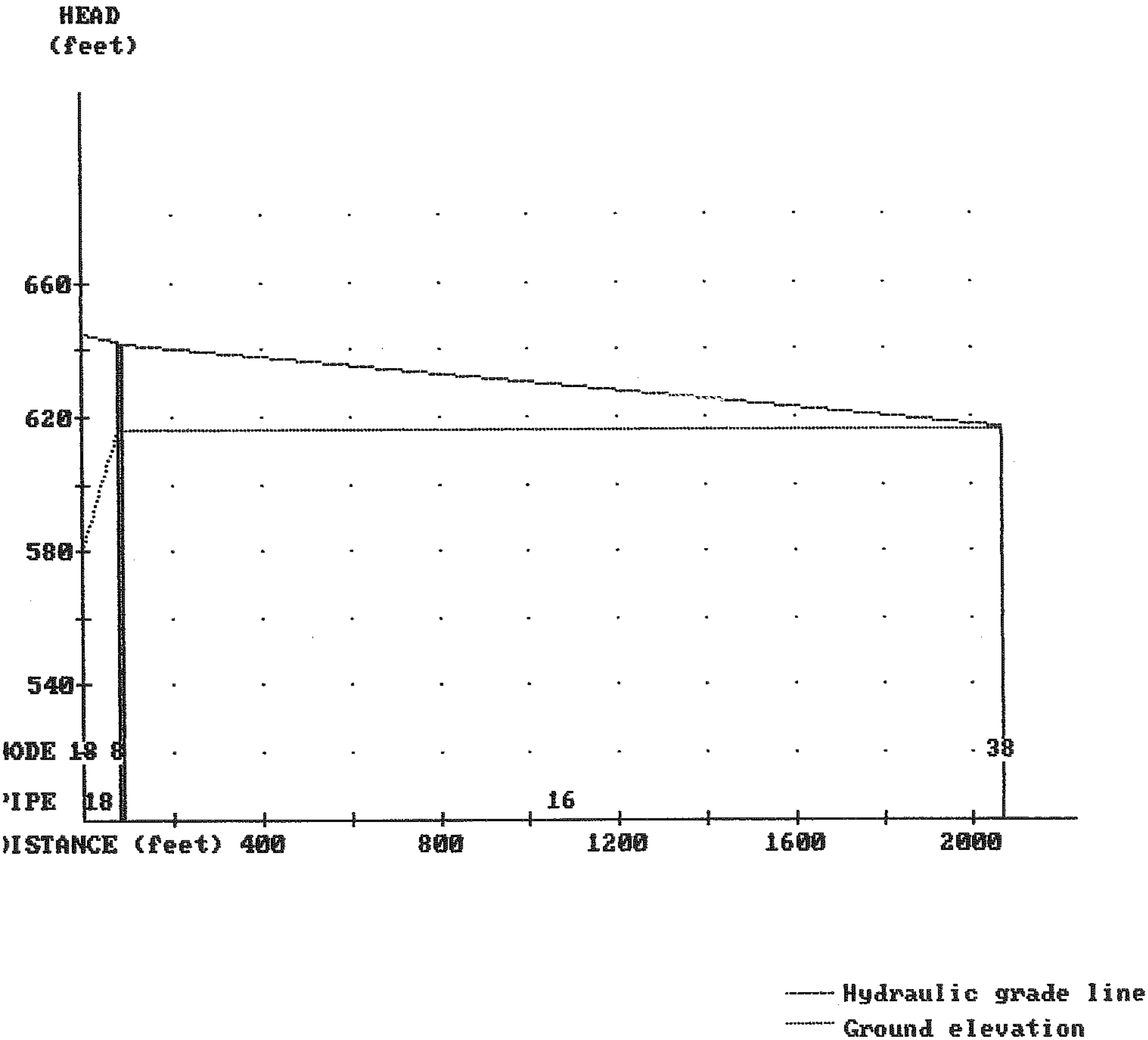
ODES: cont'd...

ode#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
12	616.50 CM1-2 LD	N/A	N/A	0.00	25.42	641.92
13	616.50 CM1-2 LD	N/A	N/A	0.00	25.40	641.90
14	616.50 CM1-2 LD	N/A	N/A	0.00	25.25	641.75
15	616.50 UNIT 1 FM	N/A	N/A	0.00	25.23	641.73
16	616.50 UNIT 1 FM	N/A	N/A	0.00	25.06	641.56
17	616.50 DISCHARGE TO PS-01	N/A	N/A	0.00	0.16	616.66
18	580.00 CM1-2 LD	N/A	N/A	35.24	1.00	581.00 fh
19	580.00 CM2-1 LD	N/A	N/A	0.00	64.45	644.45
38	616.50 PS-01	N/A	N/A	-71.27	0.00	616.50 fh

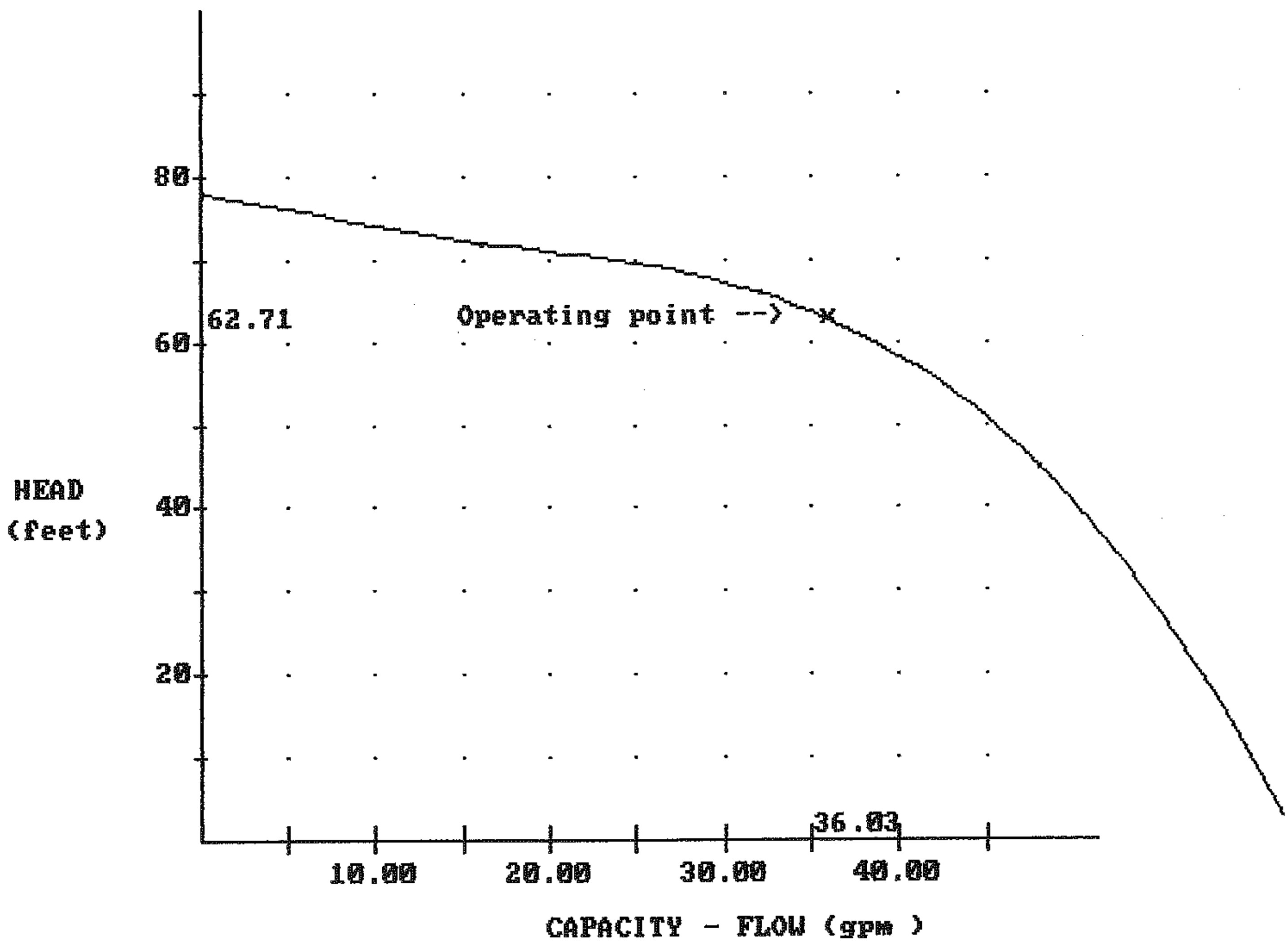
HGL for loop:1   System: CAMU_ZLD.NET -



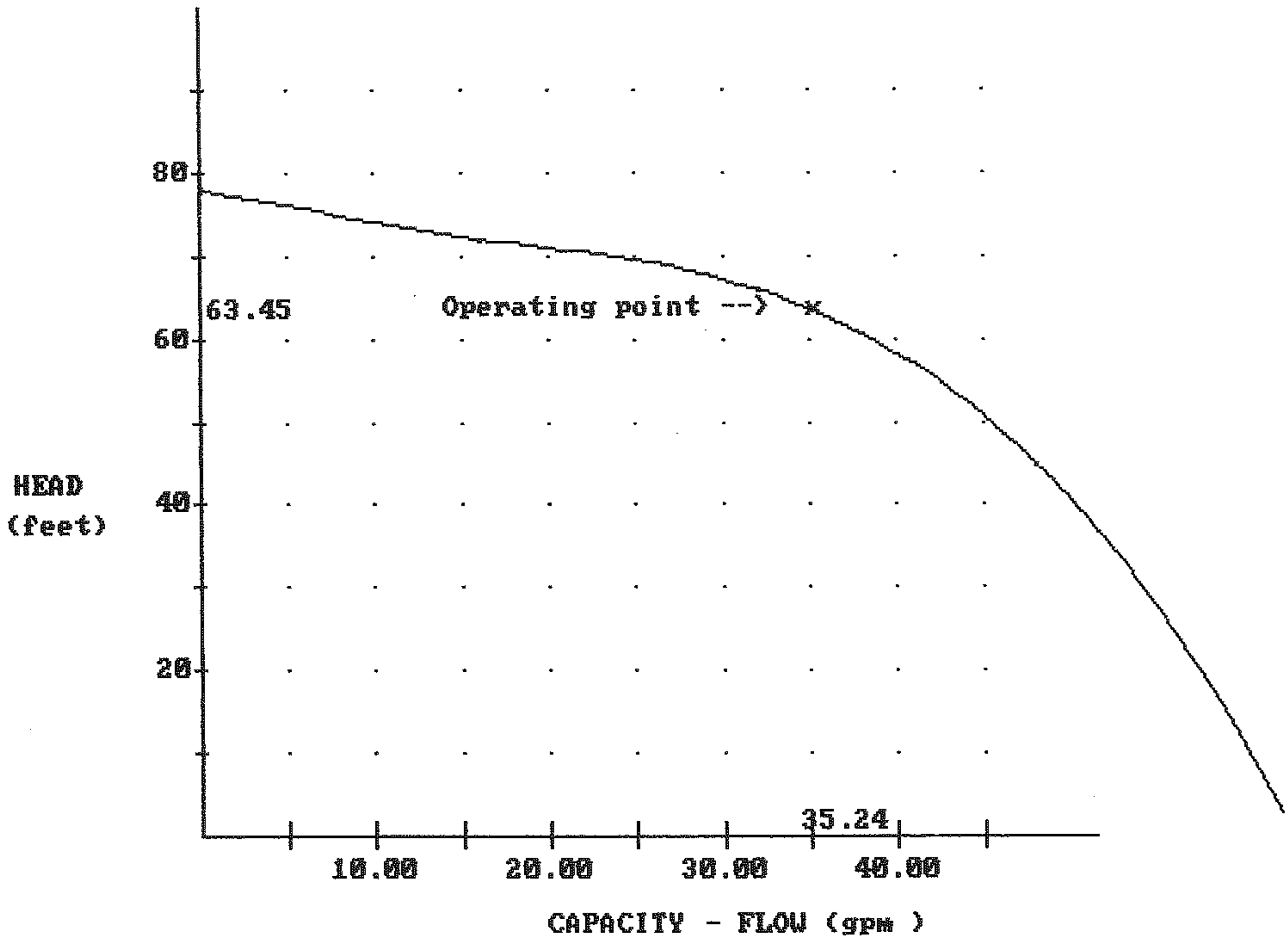
HG" for loop:2 System: CAMU_ZLD.NET -



PUMP #1 System: CAMU_ZLD.NET -



PUMP #17 System: CAMU_2LD.NET -



SUMMARY OF SYSTEM DATA
(Balanced system data for CAMU_4.NET)

PIPE HEAD LOSS EQUATION: Hazen-Williams Eq.
Tolerance for solution = 0.0100000 gpm

FLUID PROPERTIES: Specific Gravity = 1.000

ELEMENT AND NODE SUMMARY:

Total pipes	=	16	Total Nodes	=	38
Total valves & fittings	=	17			
Total Pumps (or FVH's)	=	4	Total Loops	=	4
Total Elements	=	37	Total Branches	=	0

PIPES:

El#	Length (feet)	Friction	Diameter (inches)	Flow (gpm)	Direction Node->Node		Velocity (ft/s)	Head Loss (feet)
	70.00	140	2.000	19.14	2->	3	1.95	0.63
	FM CM1-1LD 2" PUMP HOSE							
4	6.00	150	3.000	19.14	4->	5	0.87	0.01
	CM1-1 LD							
6	818.00	150	3.000	19.14	6->	7	0.87	0.90
	CM1-1 LD FM							
8	6.00	150	3.000	31.01	8->	9	1.41	0.02
	CM1-2 LD							
10	1.75	150	3.000	31.01	10->	11	1.41	0.00
	CM1-2 LD							
12	1.25	150	3.000	31.01	12->	13	1.41	0.00
	CM1-2 LD							
16	1979.00	150	3.000	88.47	16->	17	4.02	37.13
	UNIT 1 FM							
18	80.00	140	2.000	11.88	19->	7	1.21	0.30
	CM2-1 PUMP DISCHARGE HOSE 2"							
20	65.00	140	2.000	25.18	21->	22	2.57	0.97
	CM1-1 LC 2" PUMP DISCHARGE							
22	1.50	150	3.000	25.18	23->	24	1.14	0.00
	CM1-1 LC							
24	818.00	150	3.000	25.18	25->	26	1.14	1.50
	CM1-1 LC							
26	1.50	150	3.000	57.45	27->	28	2.61	0.01
	CM1-2 LC							
28	1.75	150	3.000	57.45	29->	30	2.61	0.01
	CM1-2 LC							
[illegible]	1.25	150	3.000	57.45	31->	32	2.61	0.01
	CM1-2 LC							

'IPES: cont'd...

:l#	Length (feet)	Friction	Diameter (inches)	Flow (gpm)	Direction Node->Node	Velocity (ft/s)	Head Loss (feet)
34	0.25 CM1-2 LC	150	3.000	57.45	35-> 15	2.61	0.00
36	75.00 CM1-2 LC	140	2.000	32.27	37-> 26	3.30	1.78

/ALVES & FITTINGS:

:l#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
3	Standard elbow-90 degree CM1-1 LD	0.54	3.000	19.14	3-> 4	0.01
5	Gate valve CM1-1 LD	0.14	3.000	19.14	5-> 6	0.00
7	Standard Tee-thru branch CM1-2 LD	1.08	3.000	31.01	7-> 8	0.03
9	Gate valve CM1-2 LD	0.14	3.000	31.01	9-> 10	0.00
11	Enlarge/Contract(Angle= 90.00) CM1-2 LD METER	0.00		31.01	11-> 12	0.0[illegible]
13	Swing check-valve (L/D = 50) CM1-2 LD	0.90	3.000	31.01	13-> 14	0.03
14	Gate valve CM1-2 LD	0.14	3.000	31.01	14-> 15	0.00
15	Standard Tee-thru branch UNIT 1 FM	1.08	3.000	88.47	15-> 16	0.27
21	Standard elbow-90 degree CM1-1 LC	0.54	3.000	25.18	22-> 23	0.01
23	Gate valve CM1-1 LC	0.14	3.000	25.18	24-> 25	0.00
25	Standard Tee-thru branch CM1-2 LC	1.08	3.000	57.45	26-> 27	0.11
27	Gate valve CM1-2 LC	0.14	3.000	57.45	28-> 29	0.01
29	Standard Tee-thru flo CM1-2 LC METER	0.36	3.000	57.45	30-> 31	0.04
31	Swing check-valve (L/D = 50) CM1-2 LC	0.90	3.000	57.45	32-> 33	0.10
32	Gate valve CM1-2 LC	0.14	3.000	57.45	33-> 34	0.01
33	Standard elbow-90 degree CM1-2 LC	0.54	3.000	57.45	34-> 35	0.06
37	Exit DISCHARGE TO PS-01	1.00	3.000	88.47	17-> 38	0.25

PUMPS (FVHs):

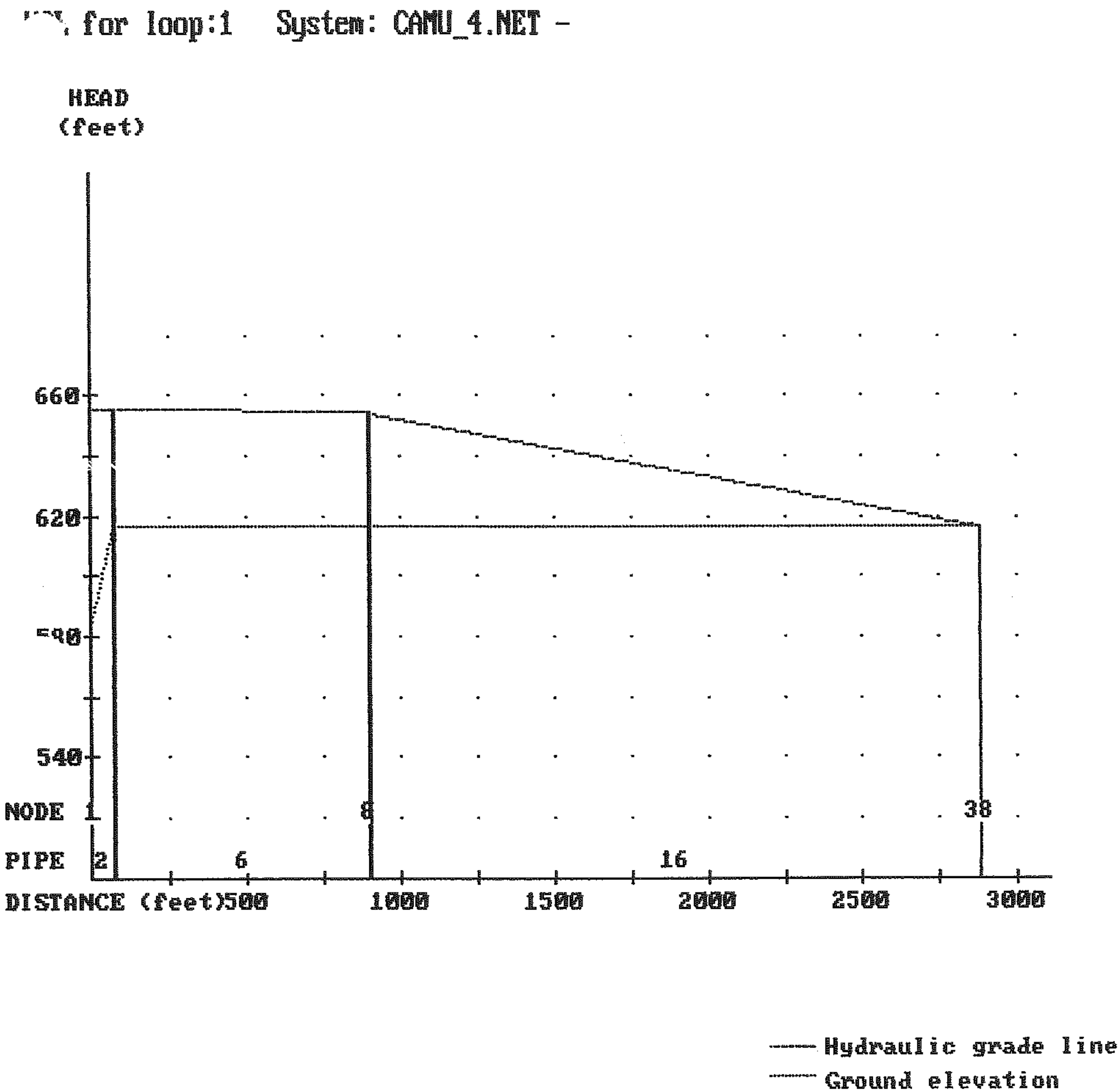
El#	Flow inc (gpm)	Shut hd (feet)	2nd (feet)	3rd (feet)	4th (feet)	Flow (gpm)	Direction Node->Node		Operating Head (feet)
1	16.00	78	72	66	45	19.14	1->	2	71.30 feet
CM1-1 LD- Suction node #1, head = 1.00 feet									
17	16.00	78	72	66	45	11.88	18->	19	73.55 feet
CM2-1 LD PUMP- Suction node #18, head = 1.00 feet									
19	16.00	78	72	66	45	25.18	20->	21	69.52 feet
CM1-1 LC PUMP- Suction node #20, head = 1.00 feet									
35	16.00	78	72	66	45	32.27	36->	37	65.81 feet
CM1-2 LC- Suction node #36, head = 1.00 feet									

NODES:

Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
1	583.50	N/A	N/A	19.14	1.00	584.50 fh
	CM1-1 LD					
2	583.50	N/A	N/A	0.00	72.30	655.80
3	616.50	N/A	N/A	0.00	38.66	655.16
	CM1-1					
	616.50	N/A	N/A	0.00	38.66	655.16
	CM1-1 LD					
5	616.50	N/A	N/A	0.00	38.65	655.15
	CM1-1 LD					
6	616.50	N/A	N/A	0.00	38.65	655.15
	CM1-1 LD					
7	616.50	N/A	N/A	0.00	37.75	654.25
	CM1-2					
8	616.50	N/A	N/A	0.00	37.71	654.21
	CM1-2 LD					
9	616.50	N/A	N/A	0.00	37.70	654.20
	CM1-2					
10	616.50	N/A	N/A	0.00	37.69	654.19
	CM1-2 LD					
11	616.50	N/A	N/A	0.00	37.69	654.19
	CM1-2 LD					
12	616.50	N/A	N/A	0.00	37.69	654.19
	CM1-2 LD					
13	616.50	N/A	N/A	0.00	37.68	654.18
	CM1-2 LD					
14	616.50	N/A	N/A	0.00	37.66	654.16
	CM1-2 LD					
15	616.50	N/A	N/A	0.00	37.65	654.15
	UNIT 1 FM					
16	616.50	N/A	N/A	0.00	37.38	653.88
	UNIT 1 FM					
	616.50	N/A	N/A	0.00	0.25	616.75
	DISCHARGE TO PS-01					

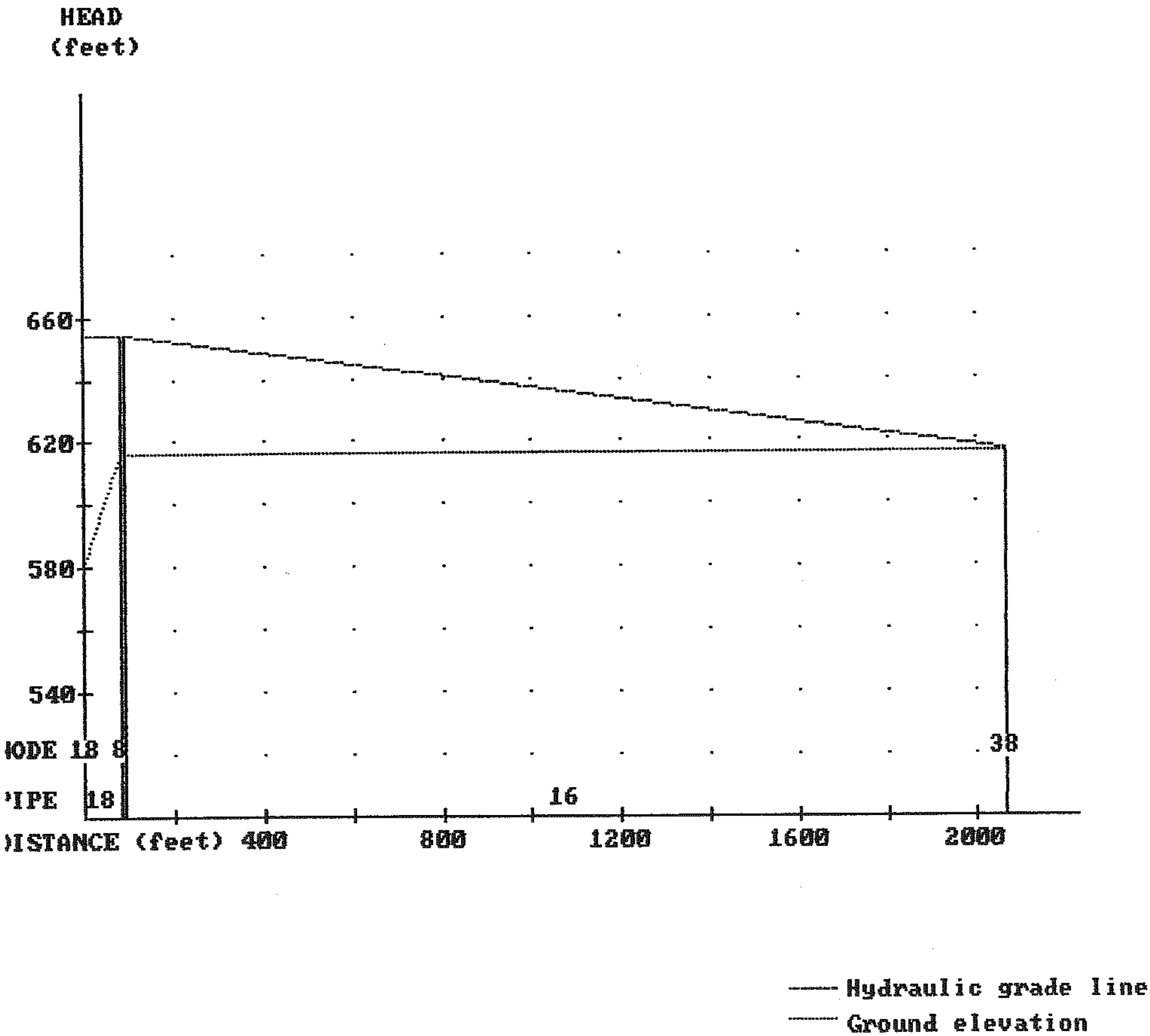
IODES: cont'd...

Iode#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
18	580.00 CM1-2 LD	N/A	N/A	11.88	1.00	581.00 fh
19	580.00 CM2-1 LD	N/A	N/A	0.00	74.55	654.55
20	586.50 CM1-1 LC	N/A	N/A	25.18	1.00	587.50 fh
21	586.50 CM1-1 LC	N/A	N/A	0.00	70.52	657.02
22	616.50 CM1-1 LC	N/A	N/A	0.00	39.55	656.05
23	616.50 CM1-1 LC	N/A	N/A	0.00	39.54	656.04
24	616.50 CM1-1 LC	N/A	N/A	0.00	39.53	656.03
25	616.50 CM1-1 LC	N/A	N/A	0.00	39.53	656.03
26	616.50 JUNCTION W/ CM1-2 LC	N/A	N/A	0.00	38.03	654.53
27	616.50 CM1-2 LC	N/A	N/A	0.00	37.91	654.41
28	616.50 CM1-2 LC	N/A	N/A	0.00	37.90	654.40
29	616.50 CM1-2 LC	N/A	N/A	0.00	37.89	654.39
30	616.50 CM1-2 LC	N/A	N/A	0.00	37.87	654.37
31	616.50 CM1-2 LC	N/A	N/A	0.00	37.83	654.33
32	616.50 CM1-2 LC	N/A	N/A	0.00	37.82	654.32
33	616.50 CM1-2 LC	N/A	N/A	0.00	37.73	654.23
34	616.50 CM1-2 LC	N/A	N/A	0.00	37.71	654.21
35	616.50 CM1-2 LC	N/A	N/A	0.00	37.66	654.16
36	589.50 CM1-2 LC	N/A	N/A	32.27	1.00	590.50 fh
37	589.50 CM1-2 LC	N/A	N/A	0.00	66.81	656.31
38	616.50 PS-01	N/A	N/A	-88.47	0.00	616.50 fh

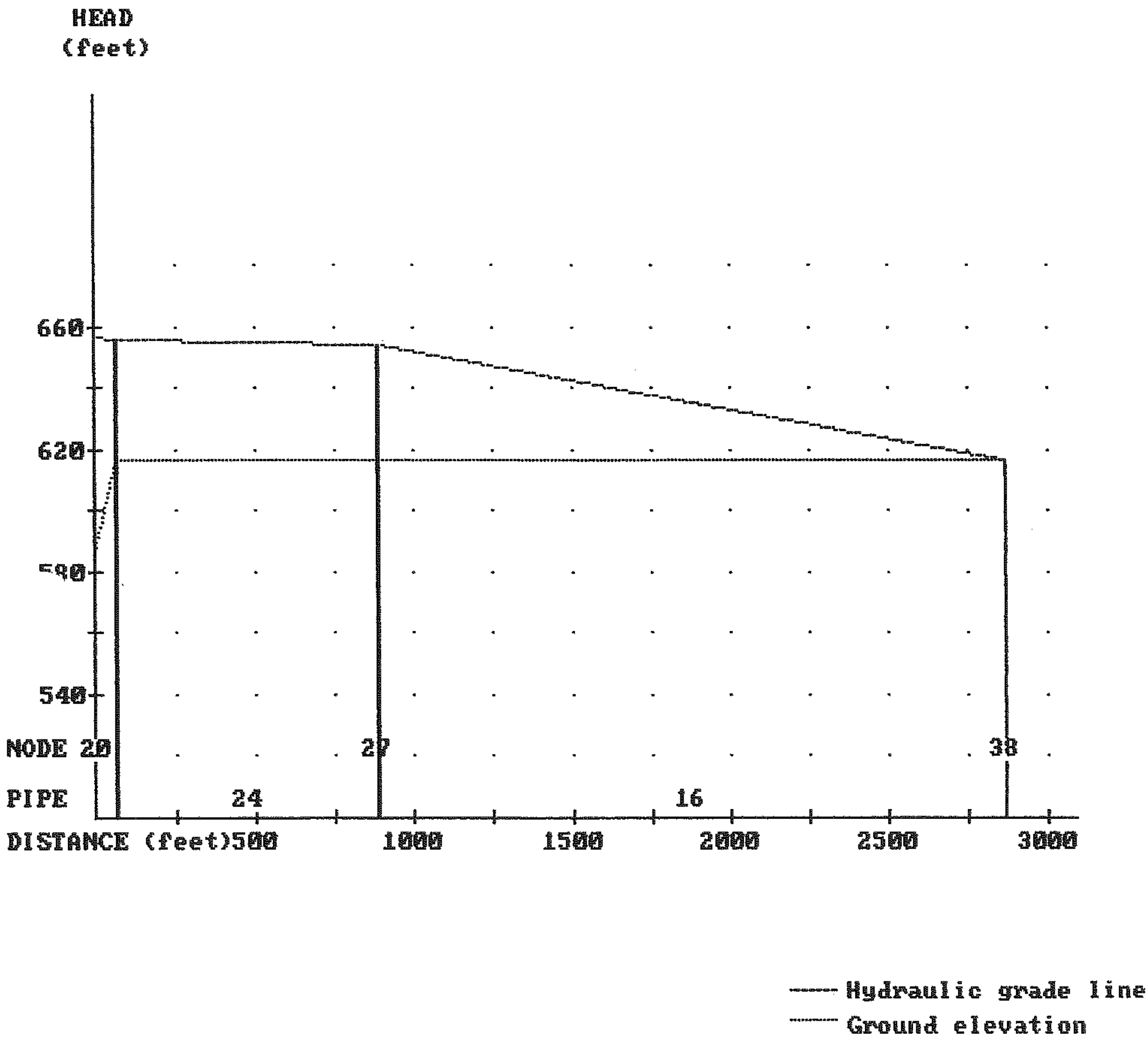


for loop:1 System: CAMU_4.NET -
HEAD
(feet)
660
620
540
NODE 1
8
38
PIPE 2
6
16
DISTANCE (feet)500
1000
1500
2000
2500
3000
Hydraulic grade line
Ground elevation

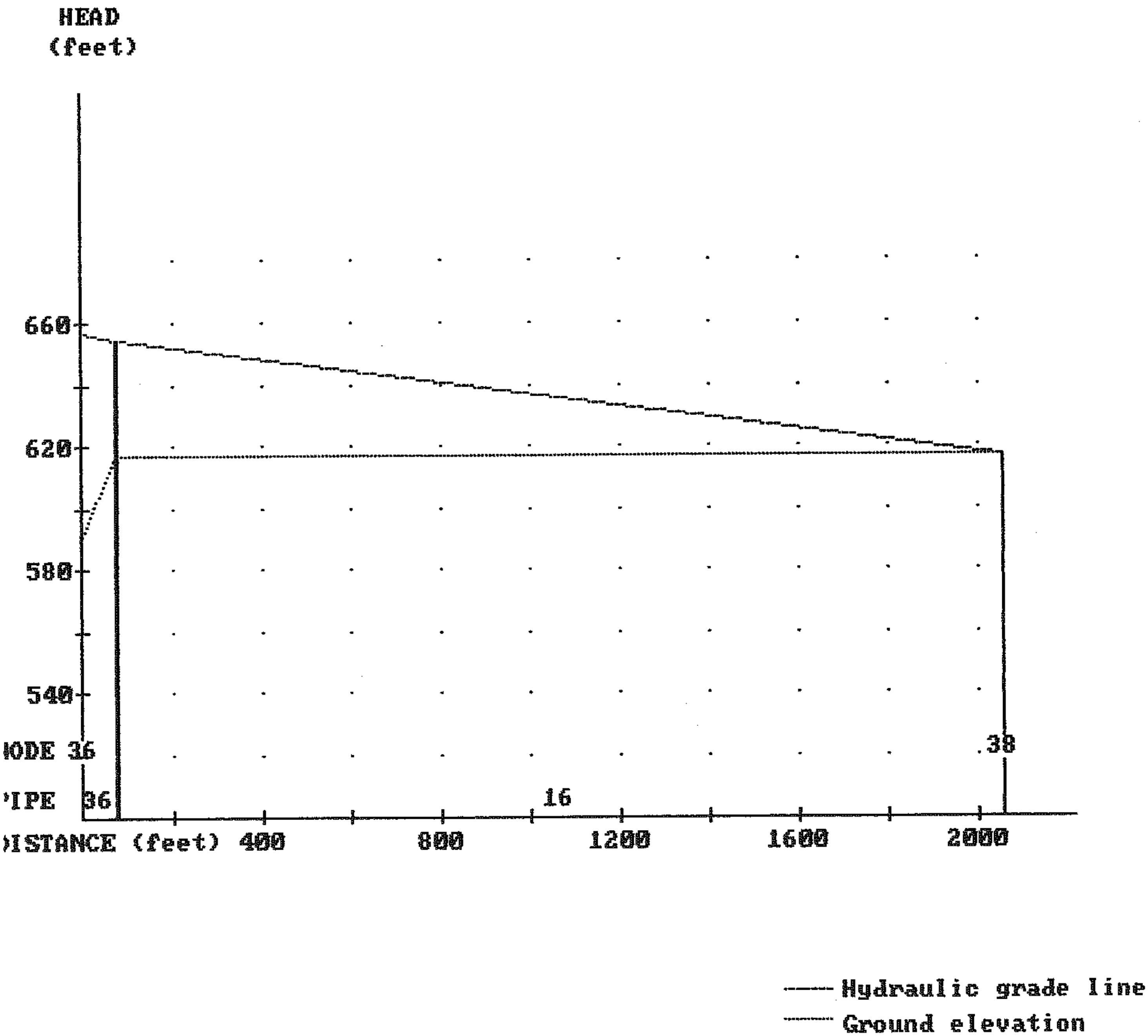
HGL for loop:2   System: CAMU_4.NET -



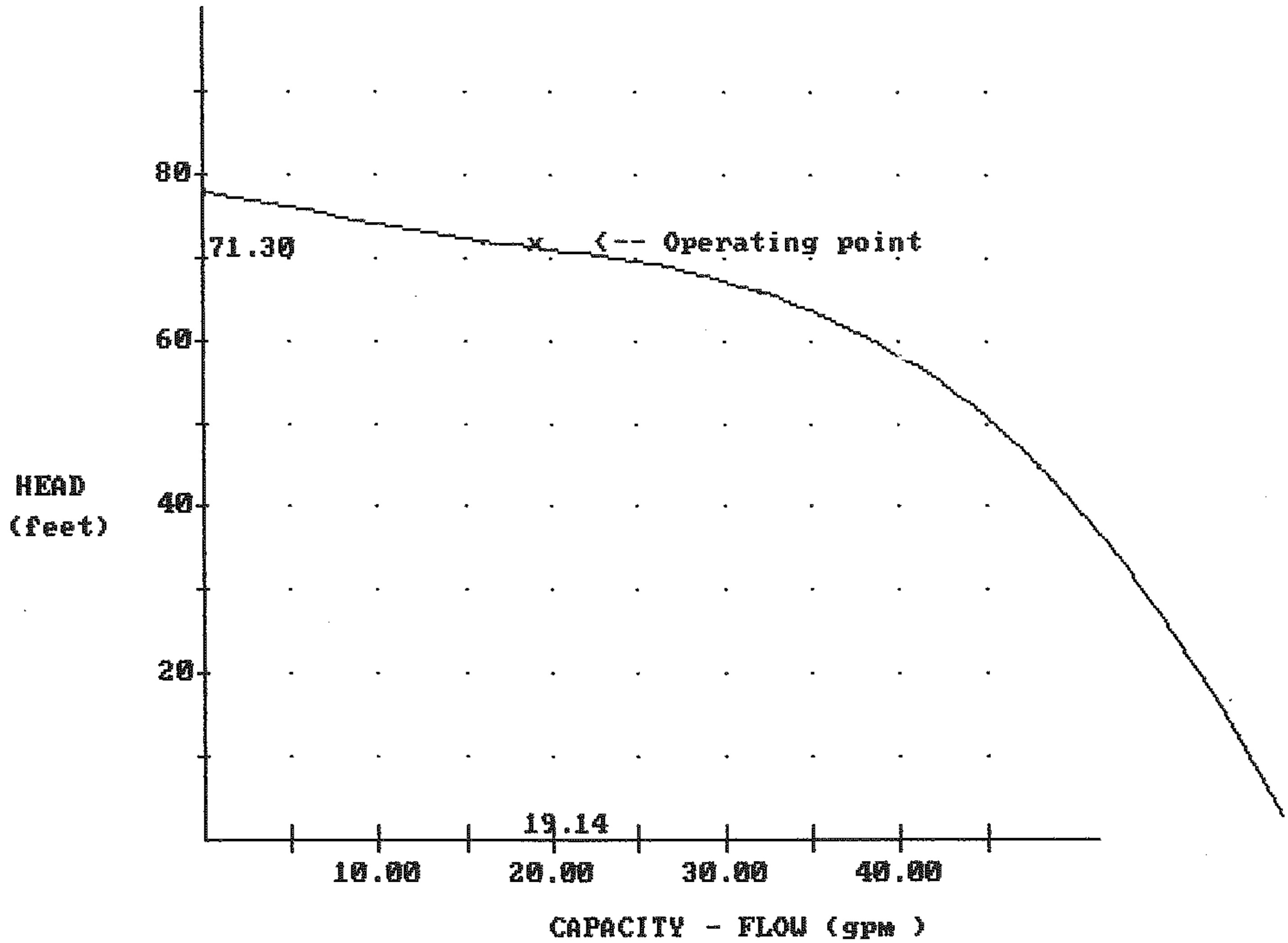
HGL for loop:3 System: CAMU_4.NET -



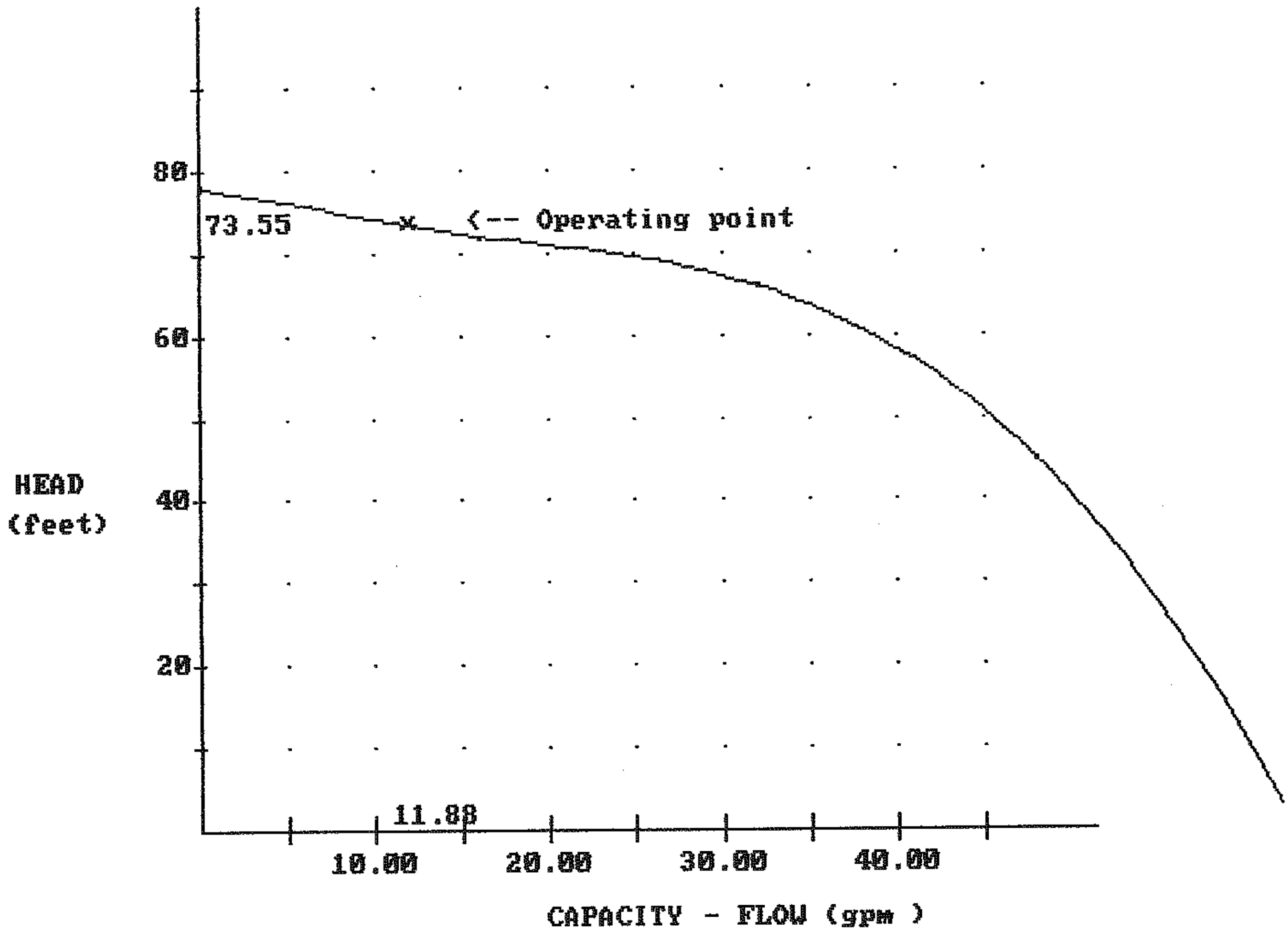
HGL for loop:4   System: CAMU_4.NET -



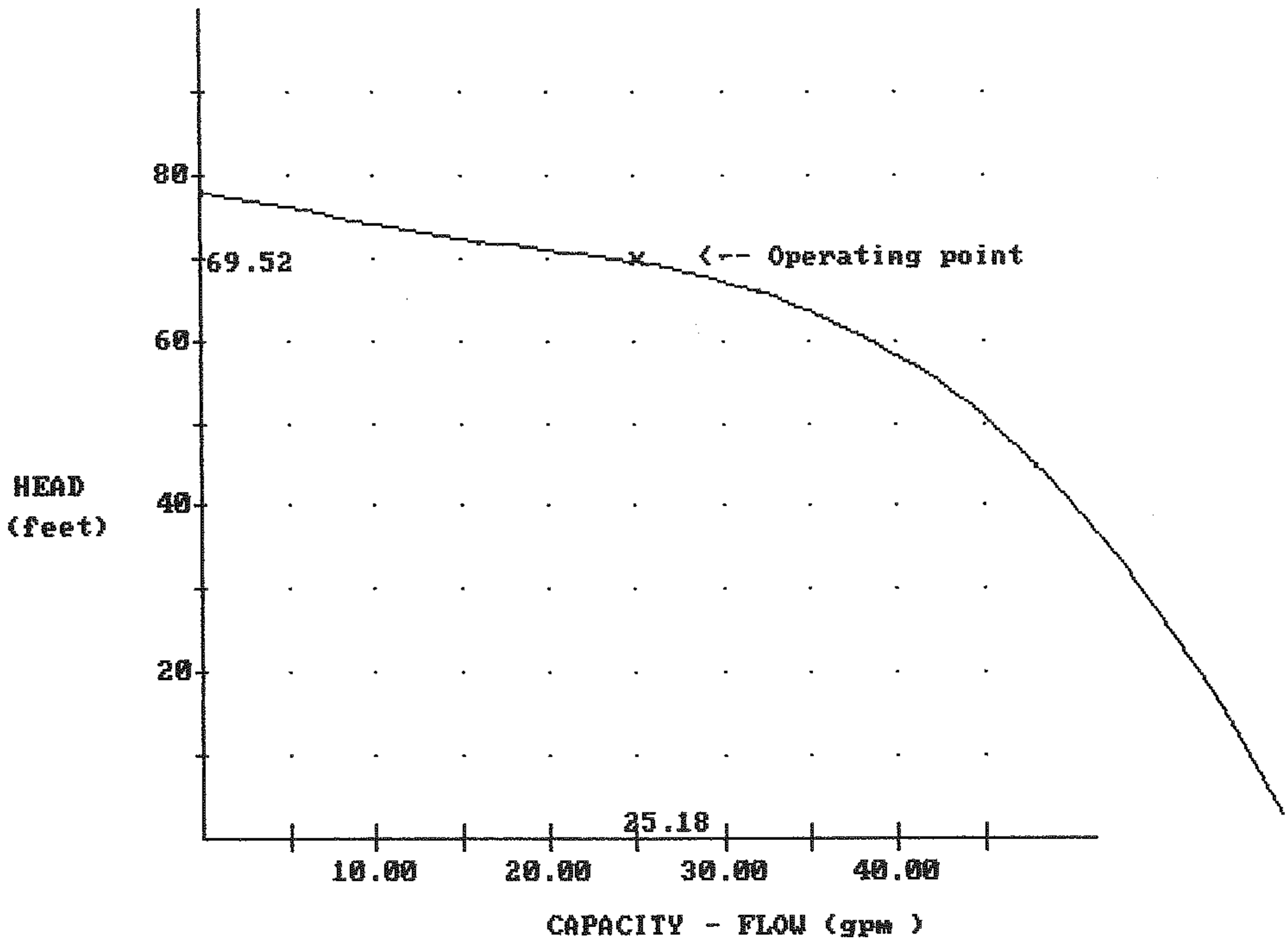
PUMP #1 System: CAMU_4.NET -



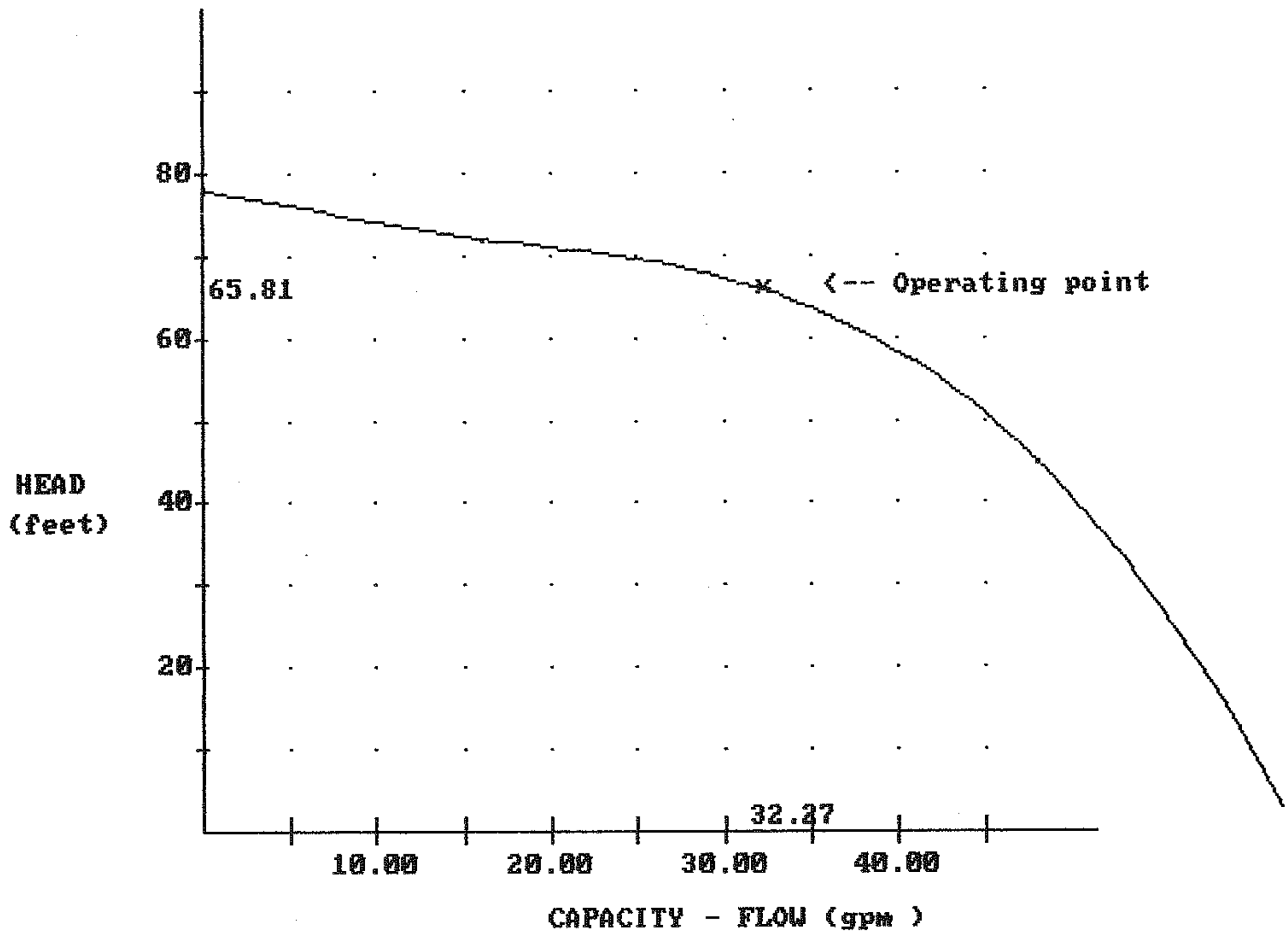
PUMP #17   System: CAMU_4.NET -



PUMP #19 System: CAMU_4.NET -



PUMP #35 System: CAMU_4.NET -



U.S. STEEL – GARY WORKS

CAMU LANDFILL

UNIT No. 2

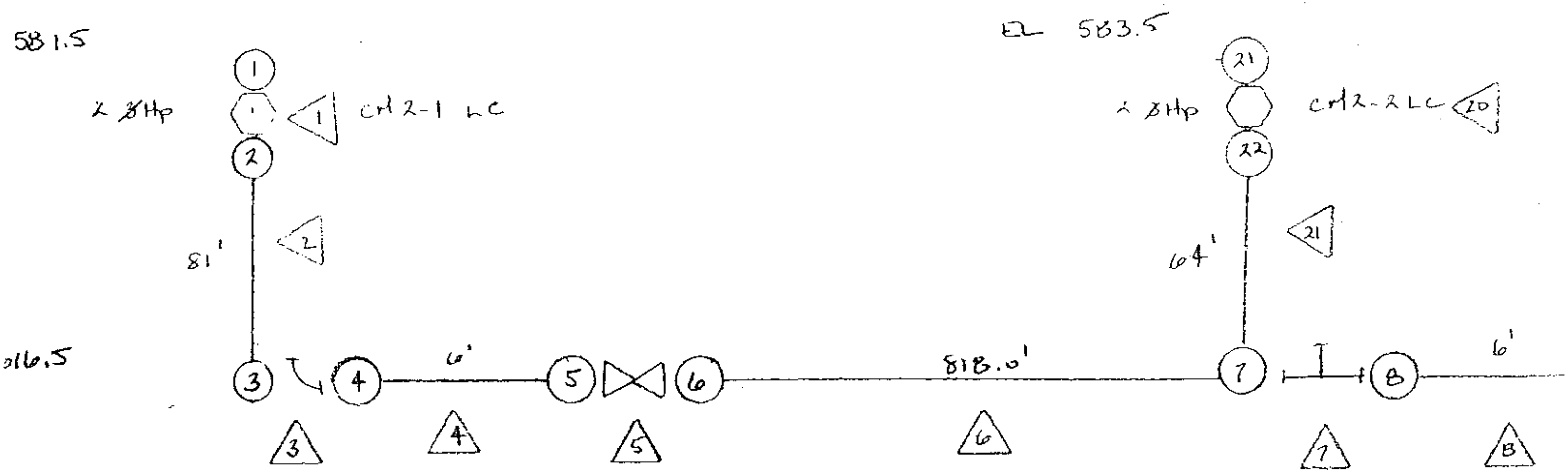
LEACHATE COLLECTION & DETECTION SYSTEM

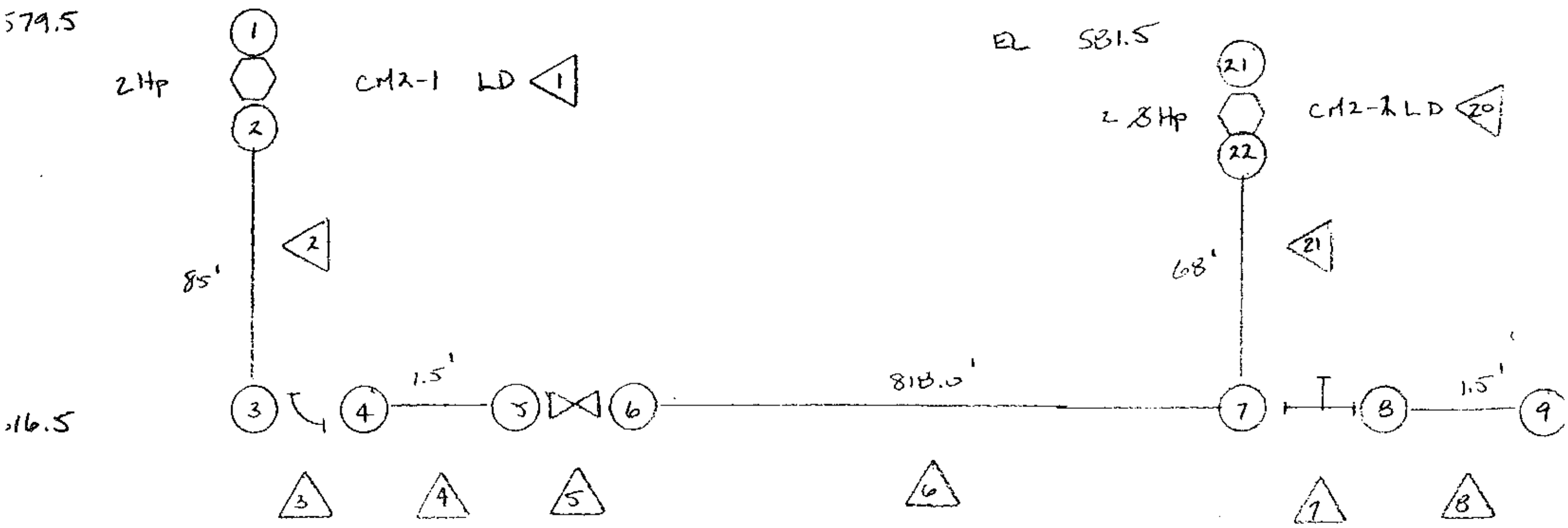
HYDRAULIC ANALYSIS

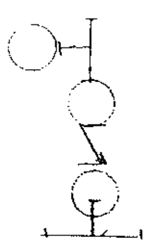
Prepared by

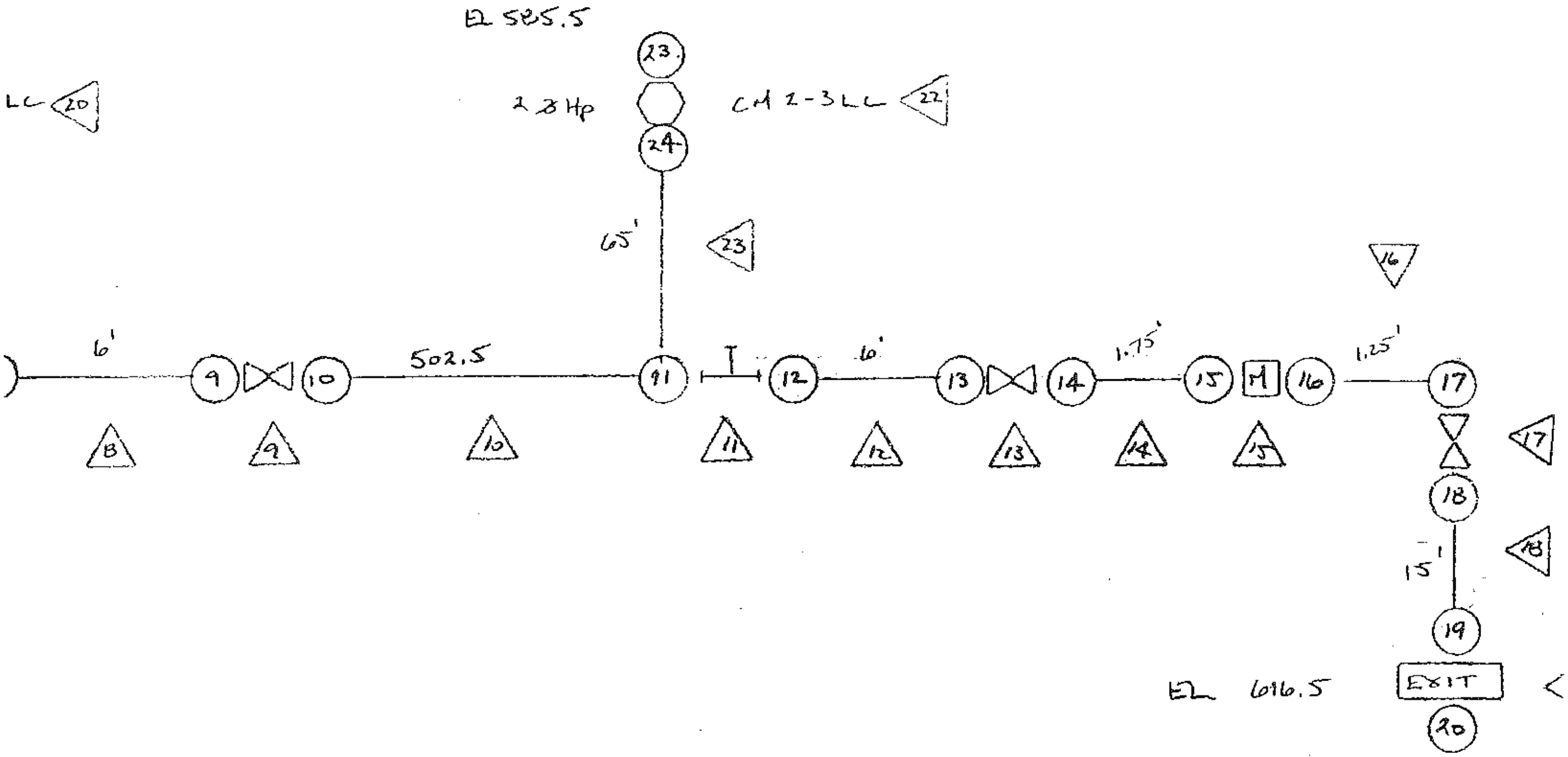
Earth Tech
3121 Butterfield Rd.
Oak Brook, IL 60523
(630) 574-2006

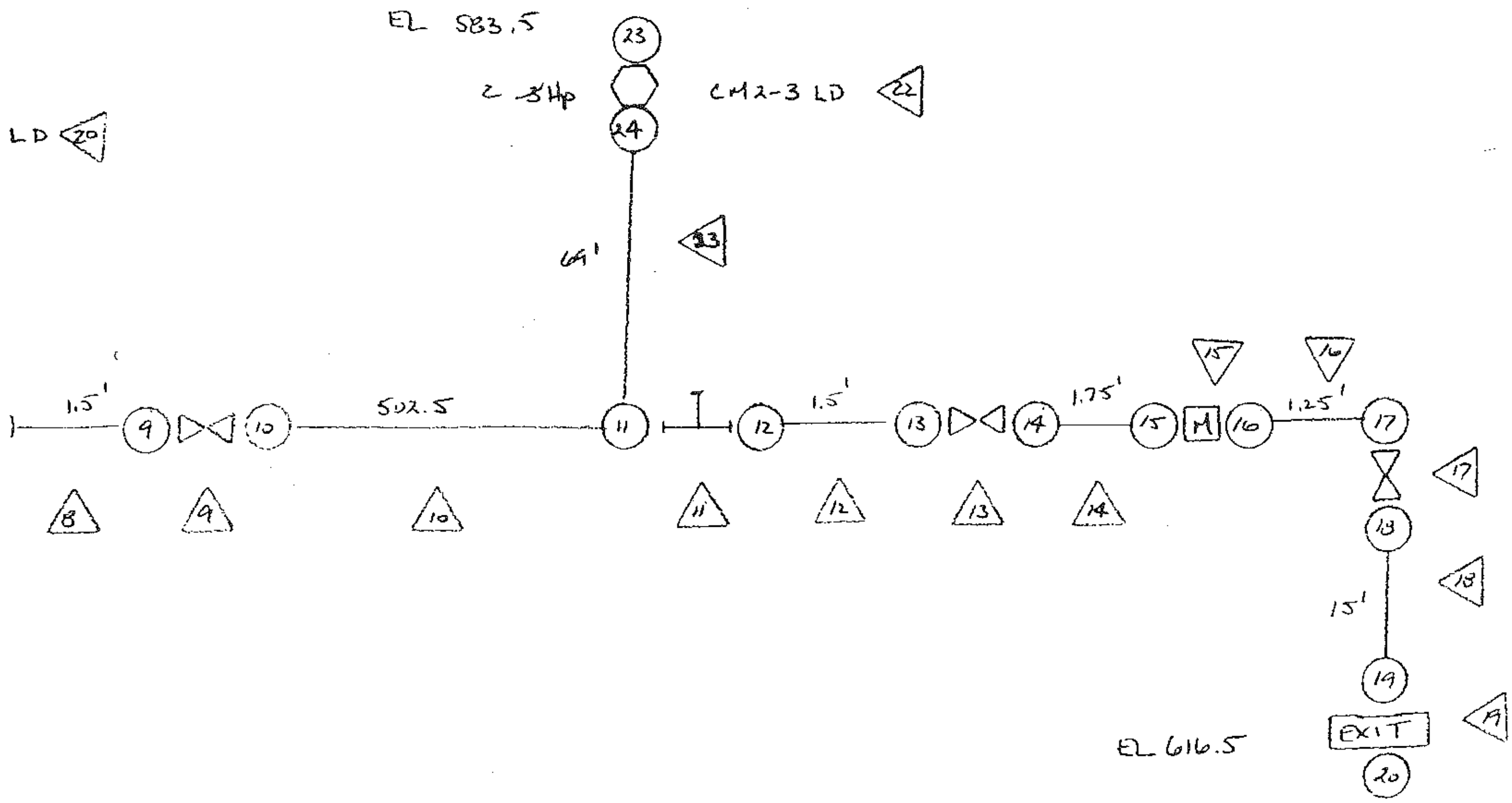
August 20, 2001


581.5
EL 583.5
2 8Hp
CM2-1 LC
2 8Hp
CM2-2 LC
81'
64'
616.5
6'
818.0'
6'


579.5
EL 581.5
2Hp
CM2-1 LD
2 8Hp
CM2-2 LD
85'
68'
616.5
1.5'
818.0'
1.5'




EL 585.5
23
2.8 Hp
24
CM 2-3 LC
22
LC
20
65'
23
16
6'
9
10
502.5
11
12
10'
13
14
1.75'
15
M
16
1.25'
17
8
9
10
11
12
13
14
15
17
18
18
15'
19
EL 616.5
EXIT
20


EL 583.5
23
2-3 Hp
24
CM 2-3 LD
22
LD
20
64'
23
1.5'
9
10
502.5
11
12
1.5'
13
14
1.75'
15
M
16
1.25'
17
15
16
8
9
10
11
12
13
14
17
18
18
15'
19
19
EXIT
EL 616.5
20

Date: 8/21/101 1:39 pm

SUMMARY OF SYSTEM DATA
(Balanced system data for CAMU2_3L.NET)

PIPE HEAD LOSS EQUATION: Hazen-Williams Eq.
Tolerance for solution = 0.0100000 gpm

FLUID PROPERTIES: Specific Gravity = 1.000

ELEMENT AND NODE SUMMARY:

Total pipes	=	11	Total Nodes	=	24
Total valves & fittings	=	9			
Total Pumps (or FVH's)	=	3	Total Loops	=	3
Total Elements	=	23	Total Branches	=	0

PIPES:

El#	Length (feet)	Friction	Diameter (inches)	Flow (gpm)	Direction Node->Node	Velocity (ft/s)	Head Loss (feet)
	81.00	140	2.000	28.05	2-> 3	2.86	1.48
	CM2-1 LC						
4	6.00	150	3.000	28.05	4-> 5	1.27	0.01
	CM2-1 LC						
6	818.00	150	3.000	28.05	6-> 7	1.27	1.83
	UNIT 2 FM						
8	6.00	150	3.000	63.09	8-> 9	2.86	0.06
	CM2-2 LC						
10	502.50	150	3.000	63.09	10-> 11	2.86	5.04
	UNIT FM						
12	6.00	150	3.000	106.76	12-> 13	4.85	0.16
	CM2-3 LC						
14	1.75	150	3.000	106.76	14-> 15	4.85	0.05
	CM2-3 LC						
16	1.25	150	3.000	106.76	16-> 17	4.85	0.03
	3"METER LC						
18	15.00	150	3.000	106.76	18-> 19	4.85	0.40
	UNIT 2 FM						
21	64.00	140	2.000	35.04	22-> 7	3.58	1.77
	CM2-2 2" HOSE						
23	65.00	140	2.000	43.67	24-> 11	4.46	2.70
	CM2-3 2" HOSE LC						

VALVES & FITTINGS:

El#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->	Node	Head Loss (feet)
3	Standard elbow-90 degree CM2-1 LC	0.54	3.000	28.05	3->	4	0.01
5	Gate valve CM2-1 LC	0.14	3.000	28.05	5->	6	0.00
7	Standard Tee-thru flo CM2-2 LC	0.36	3.000	63.09	7->	8	0.05
9	Gate valve CM2-2 LC	0.14	3.000	63.09	9->	10	0.02
11	Standard Tee-thru flo CM2-3 LC	0.36	3.000	106.76	11->	12	0.13
13	Gate valve CM2-3 LC	0.14	3.000	106.76	13->	14	0.05
15	Standard Tee-thru flo 3" METER LC	0.36	3.000	106.76	15->	16	0.13
17	Gate valve 3' METER LC	0.14	3.000	106.76	17->	18	0.05
19	Exit UNIT 2 FM LC	1.00	3.000	106.76	19->	20	0.36

PUMPS (FVHs):

El#	Flow inc (gpm)	Shut hd (feet)	2nd (feet)	3rd (feet)	4th (feet)	Flow (gpm)	Direction Node->	Node	Operating Head (feet)
1	16.00	52	48	42	30	28.05	1->	2	43.88 feet
CM2-1 LC PUMP 2 HP- Suction node #1, head = 1.00 feet									
20	16.00	52	48	42	30	35.04	21->	22	40.30 feet
CM2-2 PUMP 2HP- Suction node #21, head = 1.00 feet									
22	16.00	52	48	42	30	43.67	23->	24	34.07 feet
CM2-3 PUMP 2HP LC- Suction node #23, head = 1.00 feet									

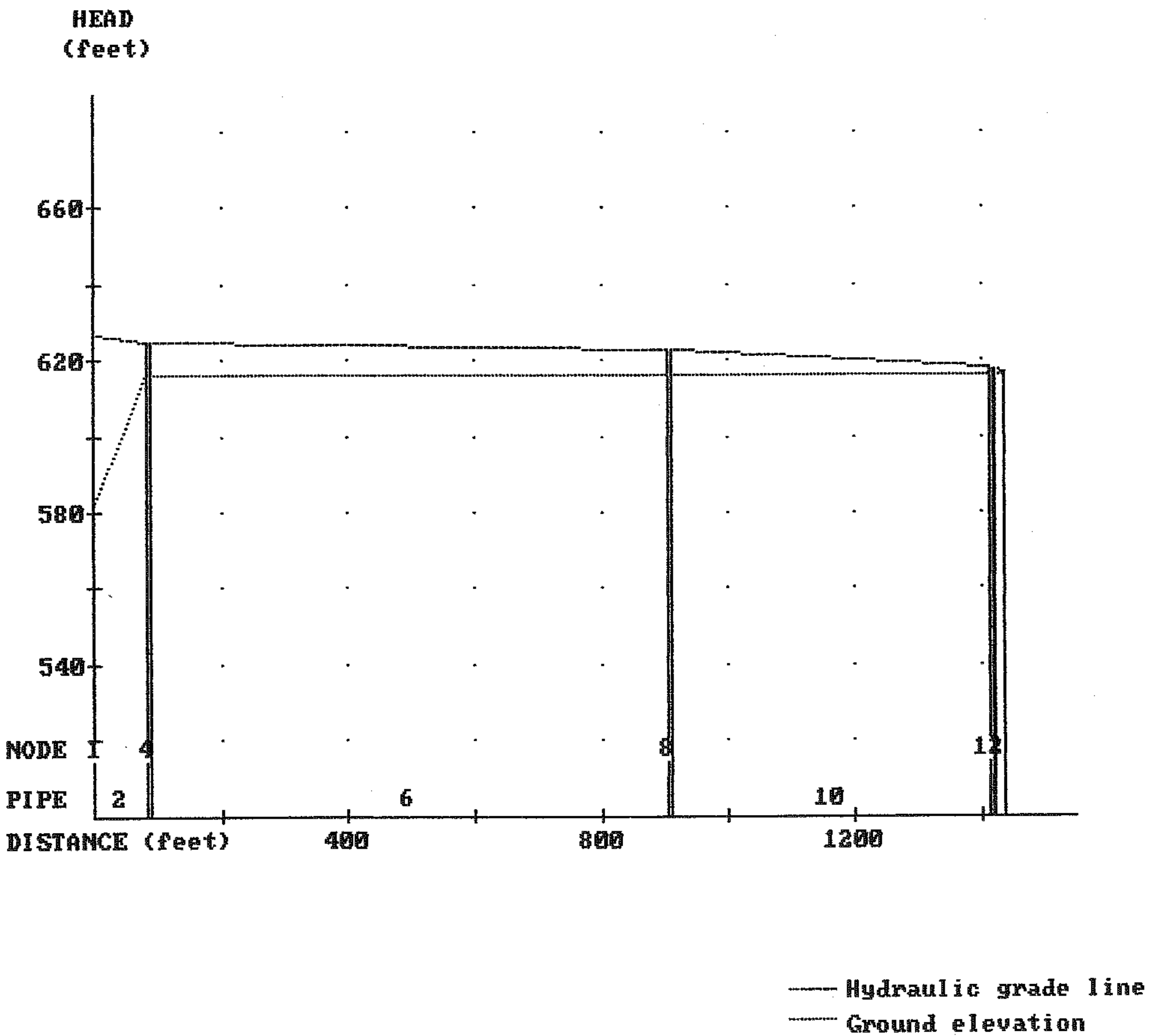
NODES:

Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
1	581.50 CM2-1 LC	N/A	N/A	28.05	1.00	582.50 fh
2	581.50 CM2-1 LC	N/A	N/A	0.00	44.88	626.38
3	616.50 CM2-1 LC	N/A	N/A	0.00	8.40	624.90
4	616.50 CM2-1 LC	N/A	N/A	0.00	8.39	624.89
5	616.50 CM2-1 LC	N/A	N/A	0.00	8.37	624.87
6	616.50 CM2-1 LC	N/A	N/A	0.00	8.37	624.87

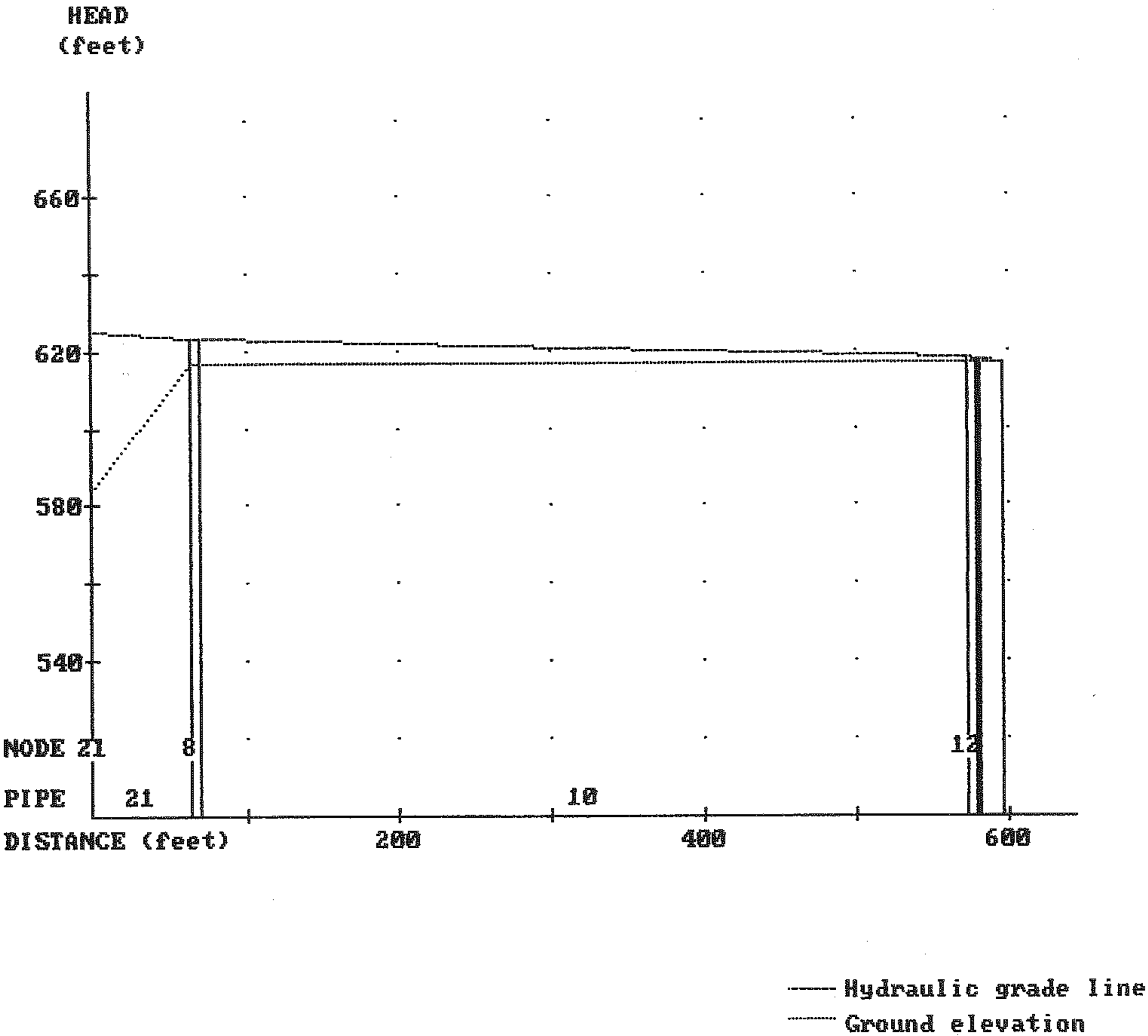
NODES: cont'd...

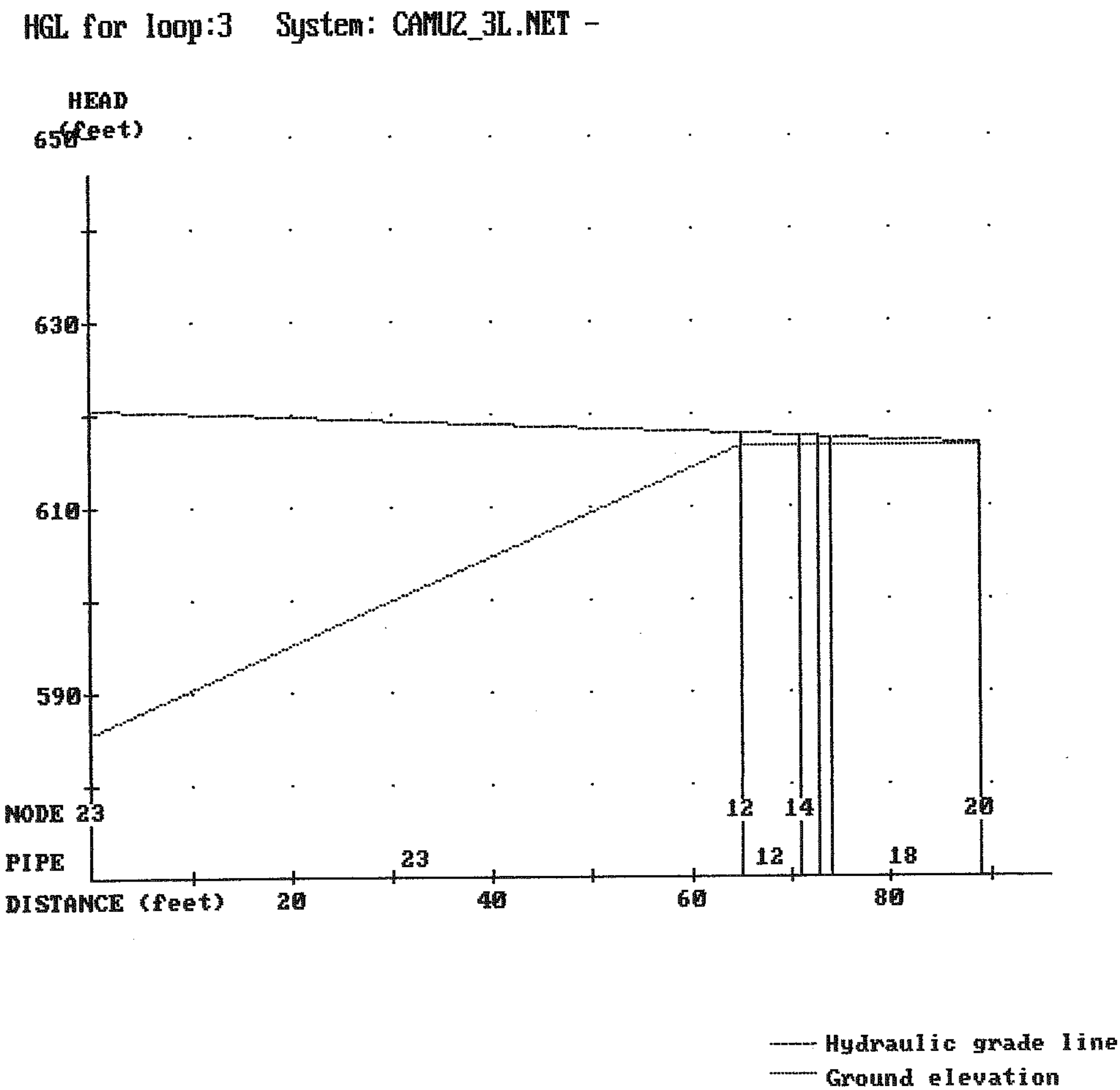
Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)	
7	616.50	N/A	N/A	0.00	6.54	623.04	
	CM2-2 LC						
8	616.50	N/A	N/A	0.00	6.49	622.99	
	CM2-2 LC						
9	616.50	N/A	N/A	0.00	6.43	622.93	
	CM2-2 LC						
10	616.50	N/A	N/A	0.00	6.41	622.91	
	CM2-2 LC						
11	616.50	N/A	N/A	0.00	1.37	617.87	
	CM2-3 LC						
12	616.50	N/A	N/A	0.00	1.24	617.74	
	CM2-3 LC						
13	616.50	N/A	N/A	0.00	1.08	617.58	
	CM2-3 LC						
14	616.50	N/A	N/A	0.00	1.03	617.53	
	CM2-3						
15	616.50	N/A	N/A	0.00	0.98	617.48	
	3" METER LC						
16	616.50	N/A	N/A	0.00	0.85	617.35	
	3" METER LC						
	616.50	N/A	N/A	0.00	0.81	617.31	
	3" METER LC						
18	616.50	N/A	N/A	0.00	0.76	617.26	
	3"METER LC						
19	616.50	N/A	N/A	0.00	0.36	616.86	
	UNIT 2 LC FM						
20	616.50	N/A	N/A	-106.76	0.00	616.50	fh
	UNIT 2 FM LC						
21	583.50	N/A	N/A	35.04	1.00	584.50	fh
	CM2-2 PUMP 2 HP						
22	583.50	N/A	N/A	0.00	41.30	624.80	
	CM2-2 PUMP 2 HP						
23	585.50	N/A	N/A	43.67	1.00	586.50	fh
	CM2-3 PUMP 2 HP						
24	585.50	N/A	N/A	0.00	35.07	620.57	
	CM2-3 LC						

HGL for loop:1   System: CAMU2_3L.NET -



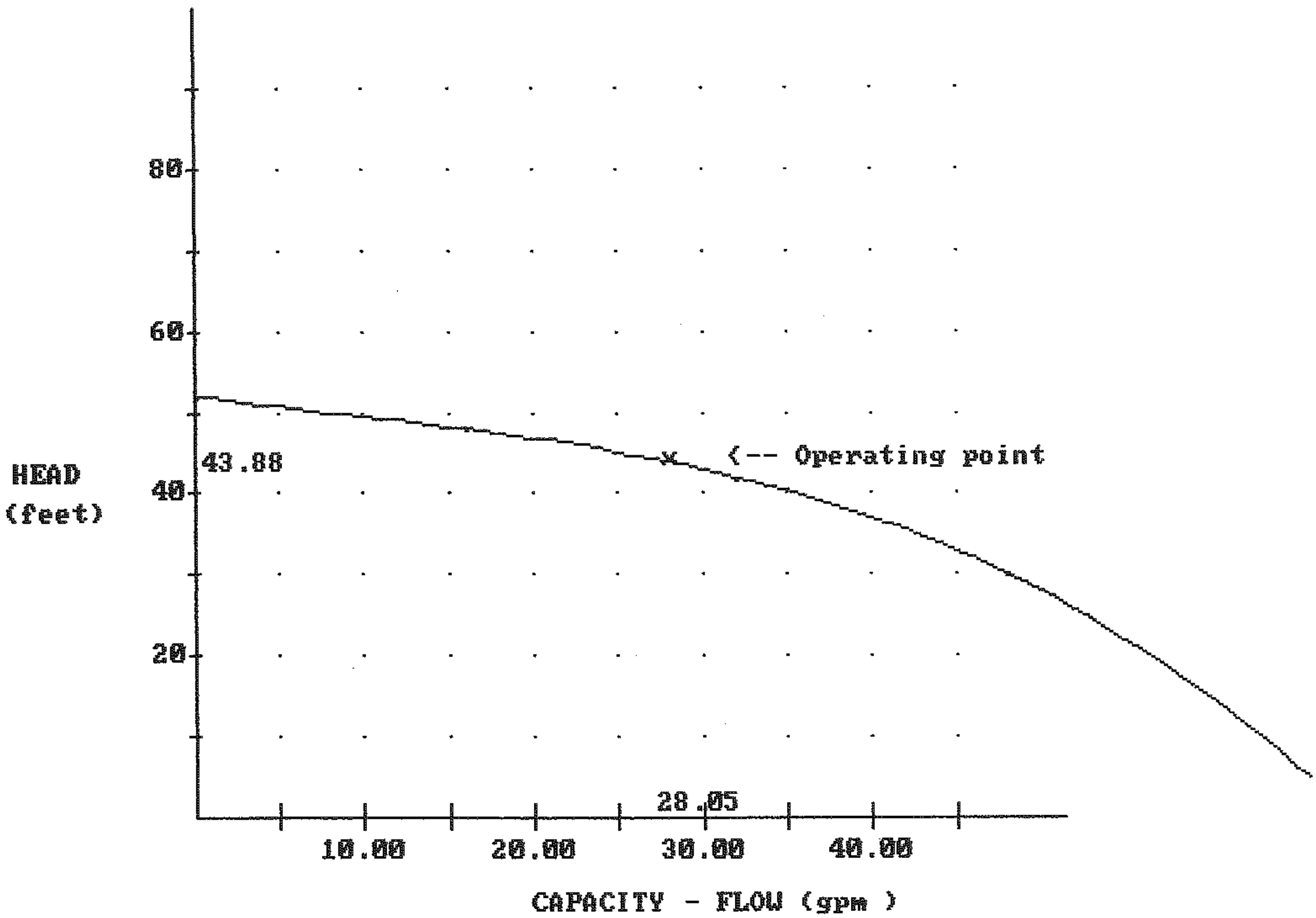
[illegible] for loop:2 System: CAMU2_3L.NET -



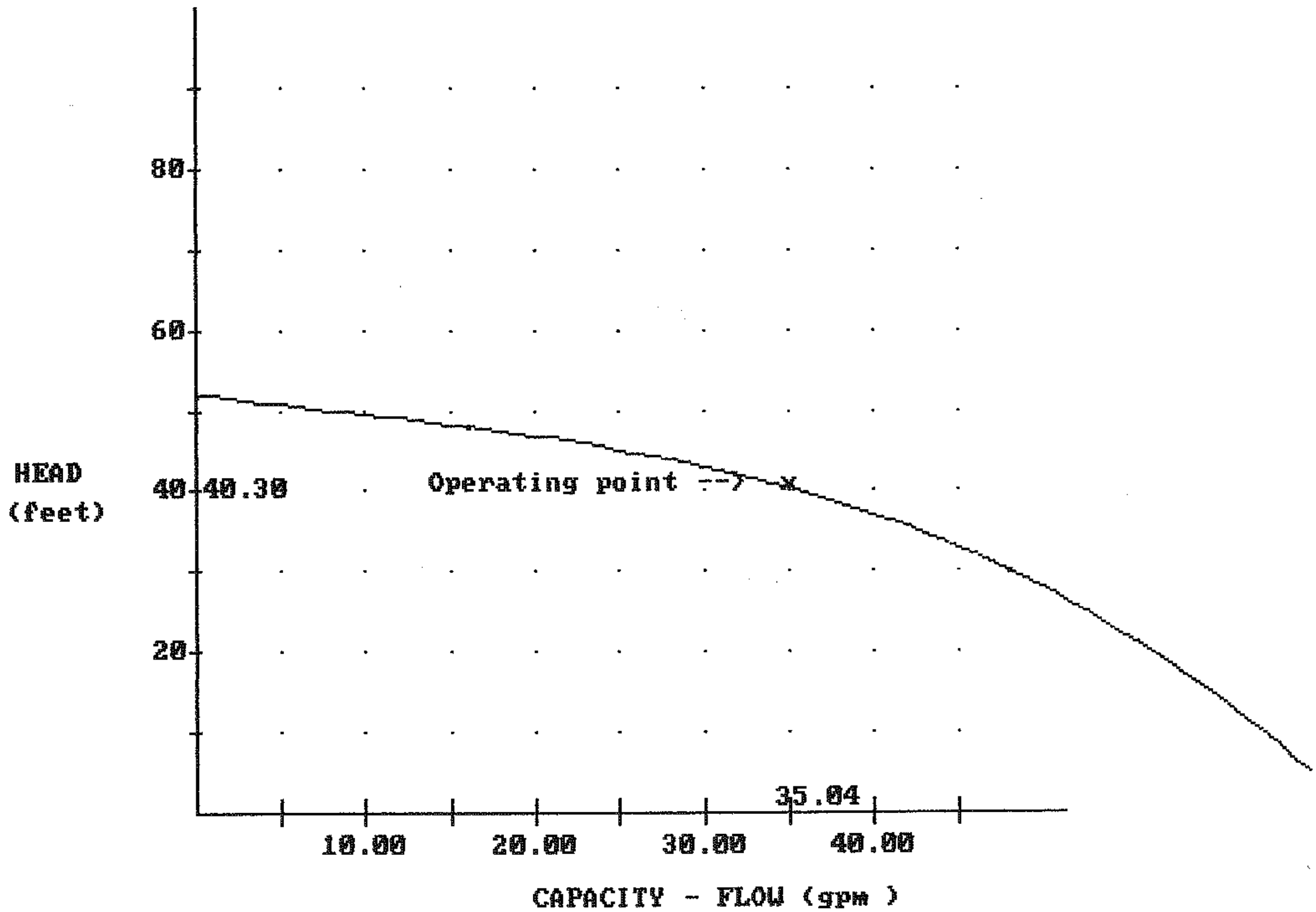


HGL for loop:3 System: CAMU2_3L.NET -
HEAD (feet)
650
630
610
590
NODE 23
12
14
20
PIPE
23
12
18
DISTANCE (feet)
20
40
60
80
Hydraulic grade line
Ground elevation

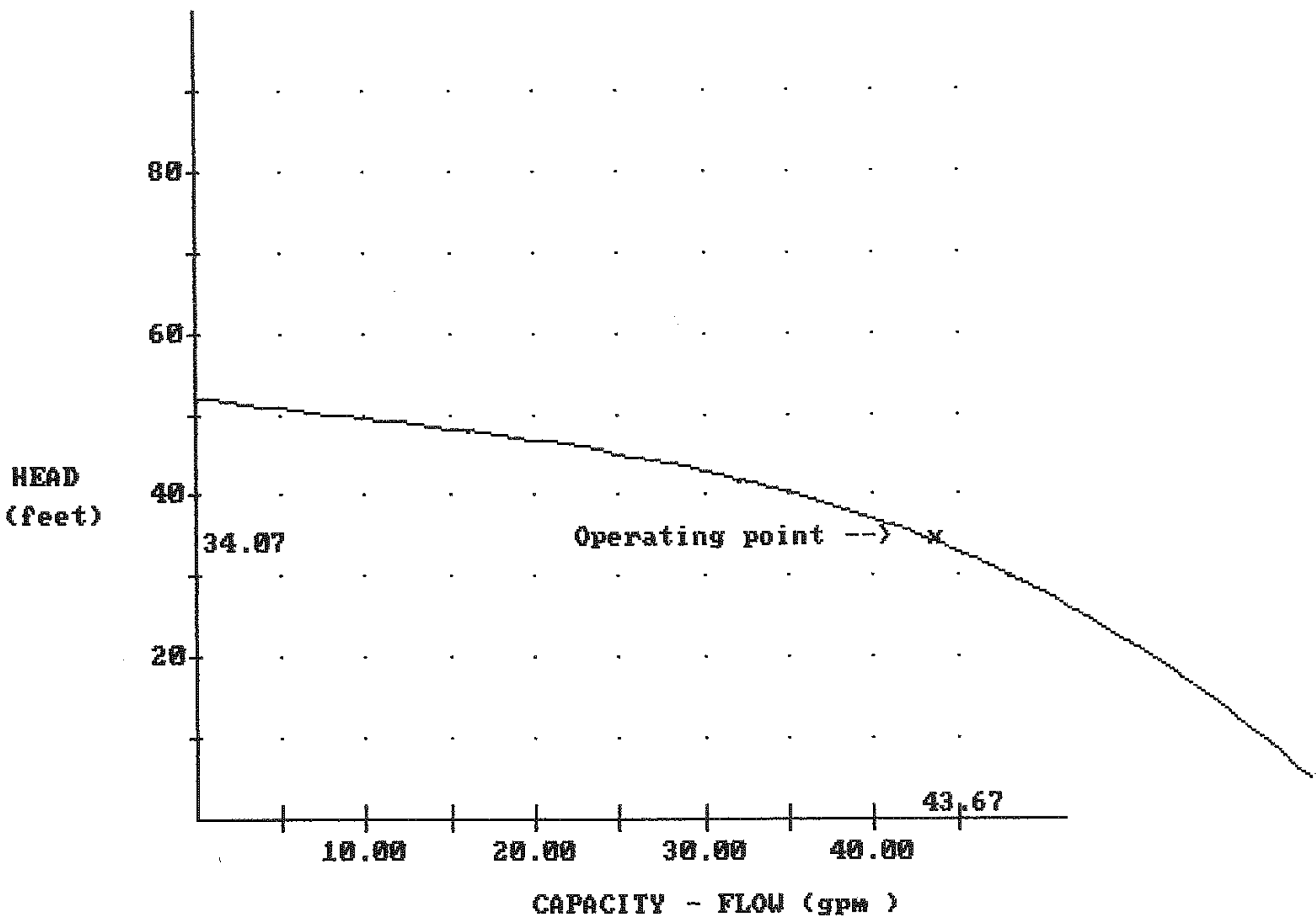
PUMP #1   System: CAMU2_3L.NET -



PUMP #20 System: CAMUZ_3L.NET -



PUMP #22 System: CAMU2_3L.NET -



SUMMARY OF SYSTEM DATA
(Balanced system data for CAMU2_1L.NET)

PIPE HEAD LOSS EQUATION: Hazen-Williams Eq.
Tolerance for solution = 0.0100000 gpm

FLUID PROPERTIES: Specific Gravity = 1.000

ELEMENT AND NODE SUMMARY:

Total pipes	=	9	Total Nodes	=	20
Total valves & fittings	=	9			
Total Pumps (or FVH's)	=	1	Total Loops	=	1
Total Elements	=	19	Total Branches	=	0

'IPES:

:l#	Length (feet)	Friction	Diameter (inches)	Flow (gpm)	Direction Node->Node	Velocity (ft/s)	Head Loss (feet)
	81.00 CM2-1 LC	140	2.000	34.36	2-> 3	3.51	2.16
4	6.00 CM2-1 LC	150	3.000	34.36	4-> 5	1.56	0.02
6	818.00 UNIT 2 FM	150	3.000	34.36	6-> 7	1.56	2.67
8	6.00 CM2-2 LC	150	3.000	34.36	8-> 9	1.56	0.02
10	502.50 UNIT FM	150	3.000	34.36	10-> 11	1.56	1.64
12	6.00 CM2-3 LC	150	3.000	34.36	12-> 13	1.56	0.02
14	1.75 CM2-3 LC	150	3.000	34.36	14-> 15	1.56	0.01
16	1.25 3"METER LC	150	3.000	34.36	16-> 17	1.56	0.00
18	15.00 UNIT 2 FM	150	3.000	34.36	18-> 19	1.56	0.05

'ALVES & FITTINGS:

:l#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
3	Standard elbow-90 degree CM2-1 LC	0.54	3.000	34.36	3-> 4	0.02
	Gate valve CM2-1 LC	0.14	3.000	34.36	5-> 6	0.01

VALVES & FITTINGS: cont'd...

El#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
7	Standard Tee-thru flo CM2-2 LC	0.36	3.000	34.36	7-> 8	0.01
9	Gate valve CM2-2 LC	0.14	3.000	34.36	9-> 10	0.01
11	Standard Tee-thru flo CM2-3 LC	0.36	3.000	34.36	11-> 12	0.01
13	Gate valve CM2-3 LC	0.14	3.000	34.36	13-> 14	0.01
15	Standard Tee-thru flo 3" METER LC	0.36	3.000	34.36	15-> 16	0.01
17	Gate valve 3' METER LC	0.14	3.000	34.36	17-> 18	0.01
19	Exit UNIT 2 FM LC	1.00	3.000	34.36	19-> 20	0.04

PUMPS (FVHs):

El#	Flow inc (gpm)	Shut hd (feet)	2nd (feet)	3rd (feet)	4th (feet)	Flow (gpm)	Direction Node->Node	Operating Head (feet)
1	16.00	52	48	42	30	34.36	1-> 2	40.70 feet

CM2-1 LC PUMP 2 HP- Suction node #1, head = 1.00 feet

NODES:

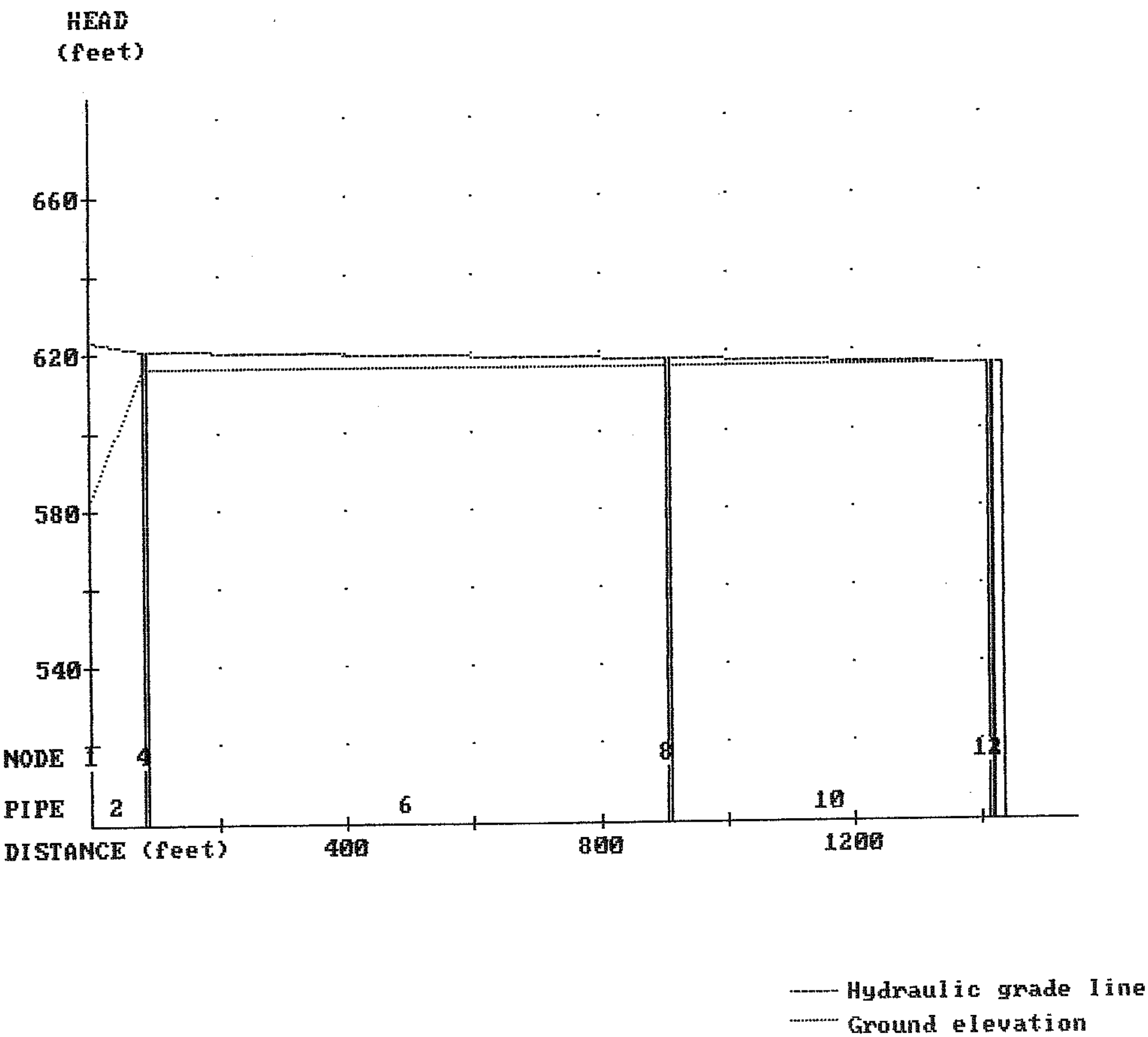
Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
1	581.50 CM2-1 LC	N/A	N/A	34.36	1.00	582.50 fh
2	581.50 CM2-1 LC	N/A	N/A	0.00	41.70	623.20
3	616.50 CM2-1 LC	N/A	N/A	0.00	4.55	621.05
4	616.50 CM2-1 LC	N/A	N/A	0.00	4.52	621.02
5	616.50 CM2-1 LC	N/A	N/A	0.00	4.51	621.01
6	616.50 CM2-1 LC	N/A	N/A	0.00	4.50	621.00
7	616.50 CM2-2 LC	N/A	N/A	0.00	1.83	618.33
8	616.50 CM2-2 LC	N/A	N/A	0.00	1.82	618.32
9	616.50 CM2-2 LC	N/A	N/A	0.00	1.80	618.30
10	616.50 CM2-2 LC	N/A	N/A	0.00	1.79	618.29

P 3
Da 8/21/101   2:23 pm

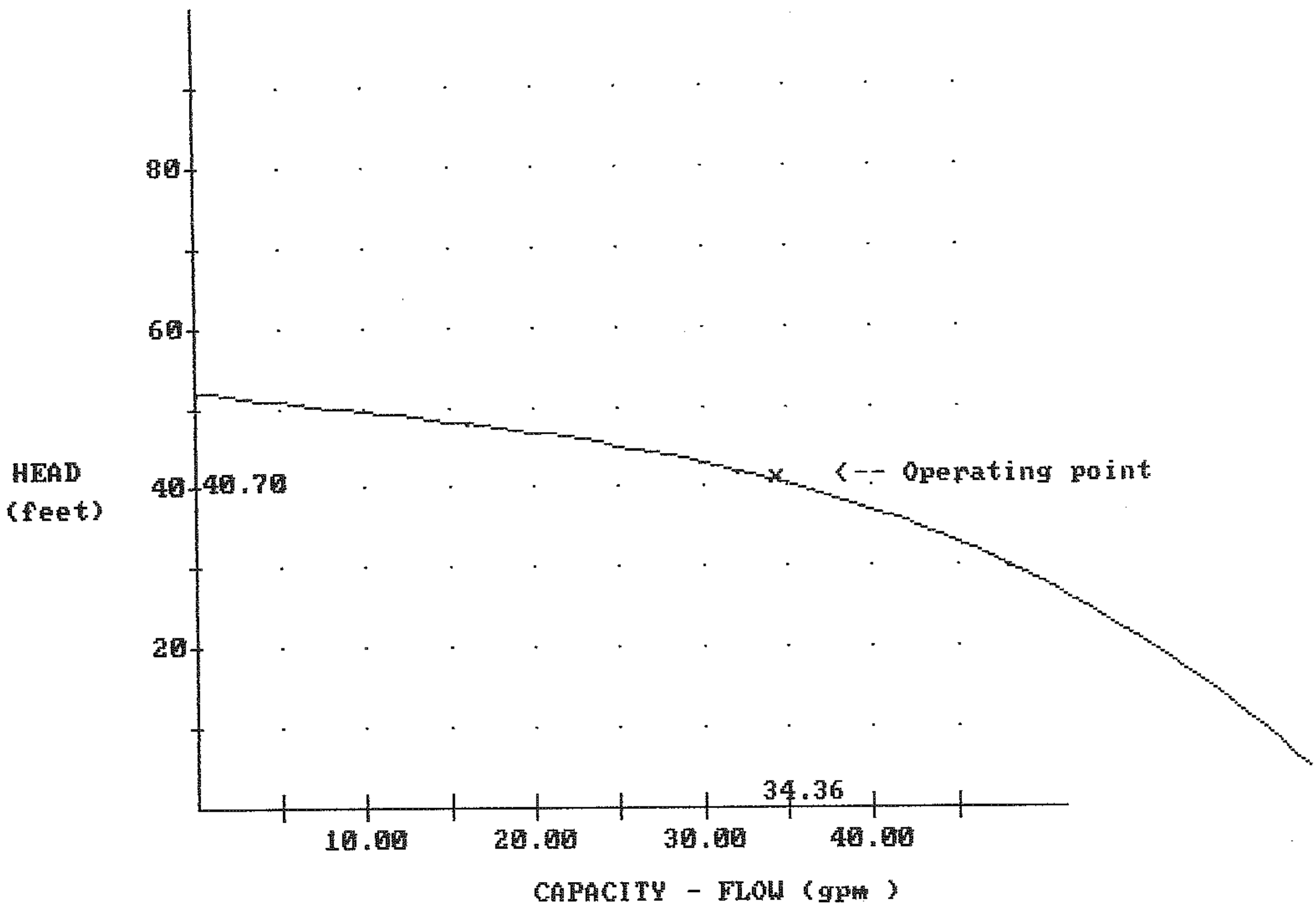
IODES: cont'd...

lode#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
11	616.50 CM2-3 LC	N/A	N/A	0.00	0.15	616.65
12	616.50 CM2-3 LC	N/A	N/A	0.00	0.14	616.64
13	616.50 CM2-3 LC	N/A	N/A	0.00	0.12	616.62
14	616.50 CM2-3	N/A	N/A	0.00	0.12	616.62
15	616.50 3" METER LC	N/A	N/A	0.00	0.11	616.61
16	616.50 3" METER LC	N/A	N/A	0.00	0.10	616.60
17	616.50 3" METER LC	N/A	N/A	0.00	0.09	616.59
18	616.50 3"METER LC	N/A	N/A	0.00	0.09	616.59
19	616.50 UNIT 2 LC FM	N/A	N/A	0.00	0.04	616.54
20	616.50 UNIT 2 FM LC	N/A	N/A	-34.36	0.00	616.50 fh

HGL for loop:1 System: CAMUZ_1L.NET -



PUMP #1 System: CAMU2_1L.NET -



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Date: 8/21/101   2:21 pm

SUMMARY OF SYSTEM DATA
(Balanced system data for CAMU2_1D.NET)

PIPE HEAD LOSS EQUATION: Hazen-Williams Eq.
Tolerance for solution = 0.0100000 gpm

FLUID PROPERTIES: Specific Gravity = 1.000

ELEMENT AND NODE SUMMARY:

Total pipes	=	9	Total Nodes	=	20
Total valves & fittings	=	9			
Total Pumps (or FVH's)	=	1	Total Loops	=	1
Total Elements	=	19	Total Branches	=	0

'IPES:

:l#	Length (feet)	Friction	Diameter (inches)	Flow (gpm)	Direction Node->Node		Velocity (ft/s)	Head Loss (feet)
_	81.00	140	2.000	32.19	2->	3	3.29	1.91
	CM2-1 LD							
4	1.50	150	3.000	32.19	4->	5	1.46	0.00
	CM2-1 LD							
6	818.00	150	3.000	32.19	6->	7	1.46	2.36
	UNIT 2 FM LD							
8	1.50	150	3.000	32.19	8->	9	1.46	0.00
	CM2-2 LD							
10	502.50	150	3.000	32.19	10->	11	1.46	1.45
	UNIT FM LD							
12	1.50	150	3.000	32.19	12->	13	1.46	0.00
	CM2-3 LD							
14	1.75	150	3.000	32.19	14->	15	1.46	0.01
	CM2-3 LD							
16	1.25	150	3.000	32.19	16->	17	1.46	0.00
	3"METER LD							
18	15.00	150	3.000	32.19	18->	19	1.46	0.04
	UNIT 2 FM LD							

'ALVES & FITTINGS:

:l#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node		Head Loss (feet)
	Standard elbow-90 degree	0.54	3.000	32.19	3->	4	0.02
	CM2-1 LD						
5	Gate valve	0.14	3.000	32.19	5->	6	0.00
	CM2-1 LD						

VALVES & FITTINGS: cont'd...

El#	Description	Fric	Dia (inches)	Flow (gpm)	Direction Node->Node	Head Loss (feet)
7	Standard Tee-thru flo CM2-2 LD	0.36	3.000	32.19	7-> 8	0.01
9	Gate valve CM2-2 LD	0.14	3.000	32.19	9-> 10	0.00
11	Standard Tee-thru flo CM2-3 LD	0.36	3.000	32.19	11-> 12	0.01
13	Gate valve CM2-3 LD	0.14	3.000	32.19	13-> 14	0.00
15	Standard Tee-thru flo 3" METER LD	0.36	3.000	32.19	15-> 16	0.01
17	Gate valve 3' METER LD	0.14	3.000	32.19	17-> 18	0.00
19	Exit UNIT 2 FM LD	1.00	3.000	32.19	19-> 20	0.03

PUMPS (FVHs):

El#	Flow inc (gpm)	Shut hd (feet)	2nd (feet)	3rd (feet)	4th (feet)	Flow (gpm)	Direction Node->Node	Operating Head (feet)
1	16.00	52	48	42	30	32.19	1-> 2	41.90 feet

CM2-1 LD PUMP 2 HP- Suction node #1, head = 1.00 feet

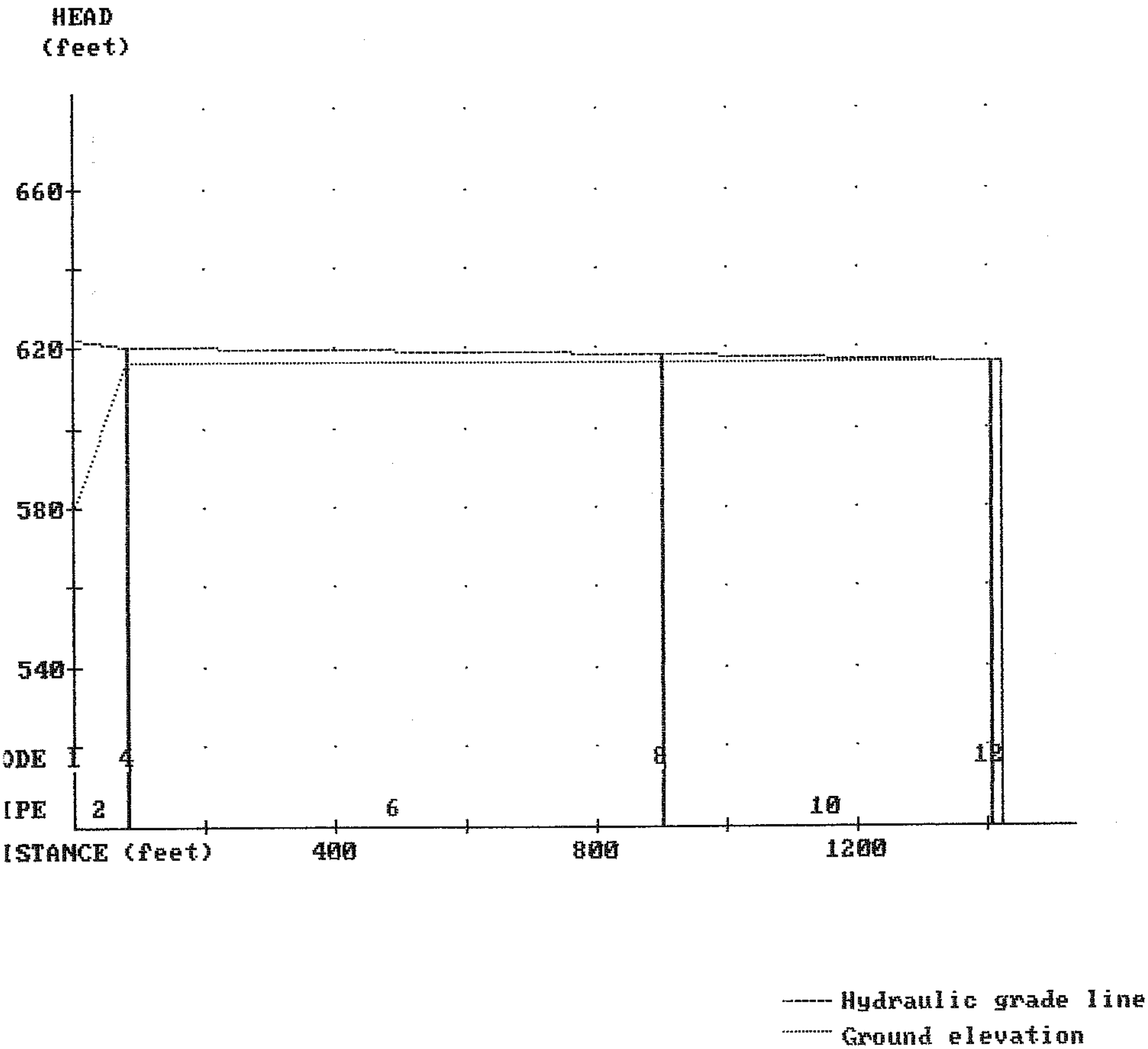
NODES:

Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
1	579.50 CM2-1 LD	N/A	N/A	32.19	1.00	580.50 fh
2	579.50 CM2-1 LD	N/A	N/A	0.00	42.90	622.40
3	616.50 CM2-1 LD	N/A	N/A	0.00	3.99	620.49
4	616.50 CM2-1 LD	N/A	N/A	0.00	3.97	620.47
5	616.50 CM2-1 LC	N/A	N/A	0.00	3.97	620.47
6	616.50 CM2-1 LD	N/A	N/A	0.00	3.96	620.46
7	616.50 CM2-2 LD	N/A	N/A	0.00	1.60	618.10
8	616.50 CM2-2 LD	N/A	N/A	0.00	1.58	618.08
9	616.50 CM2-2 LD	N/A	N/A	0.00	1.58	618.08
10	616.50 CM2-2 LD	N/A	N/A	0.00	1.58	618.08

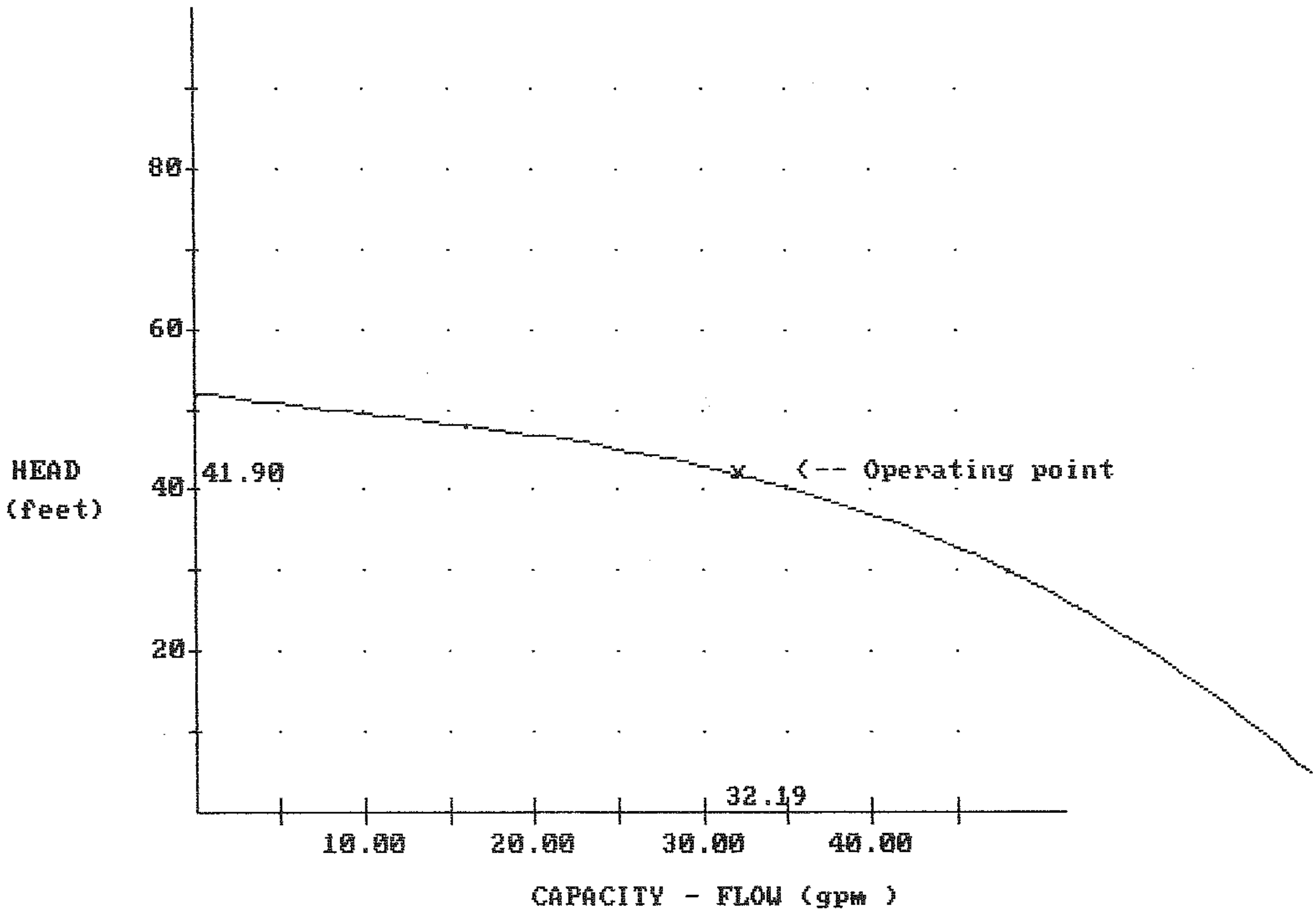
ODES: cont'd...

ode#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)	HGL (feet)
11	616.50	N/A	N/A	0.00	0.12	616.62
	CM2-3 LD					
12	616.50	N/A	N/A	0.00	0.11	616.61
	CM2-3 LD					
13	616.50	N/A	N/A	0.00	0.11	616.61
	CM2-3 LD					
14	616.50	N/A	N/A	0.00	0.10	616.60
	CM2-3 LD					
15	616.50	N/A	N/A	0.00	0.10	616.60
	3" METER LD					
16	616.50	N/A	N/A	0.00	0.08	616.58
	3" METER LD					
17	616.50	N/A	N/A	0.00	0.08	616.58
	3" METER LD					
18	616.50	N/A	N/A	0.00	0.08	616.58
	3"METER LD					
19	616.50	N/A	N/A	0.00	0.03	616.53
	UNIT 2 FM LD					
20	616.50	N/A	N/A	-32.19	0.00	616.50 fh
	UNIT 2 FM LD					

HGL for loop:1   System: CAMU2_1D.NET -



PUMP #1 System: CAMUZ_1D.NET -



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Date: 8/21/101 4:19 pm

SUMMARY OF SYSTEM DATA
Initial system data for CAMU2_3D.NET

PIPE HEAD LOSS EQUATION: Hazen-Williams Eq.
Tolerance for solution = 0.0100000 gpm

FLUID PROPERTIES: Specific Gravity = 1.000

ELEMENT AND NODE SUMMARY:

Total pipes	=	11	Total Nodes	=	24
Total valves & fittings	=	9			
Total Pumps (or FVH's)	=	3	Total Loops	=	3
Total Elements	=	23	Total Branches	=	0

PIPES:

El#	Length (feet)	Friction	Diameter (inches)
	81.00	140	2.000
	CM2-1 LD		
4	1.50	150	3.000
	CM2-1 LD		
6	818.00	150	3.000
	UNIT 2 FM LD		
8	1.50	150	3.000
	CM2-2 LD		
10	502.50	150	3.000
	UNIT FM LD		
12	1.50	150	3.000
	CM2-3 LD		
14	1.75	150	3.000
	CM2-3 LD		
16	1.25	150	3.000
	3"METER LD		
18	15.00	150	3.000
	UNIT 2 FM LD		
21	68.00	140	2.000
	CM2-2 2" HOSE LD		
23	69.00	140	2.000
	CM2-3 2" HOSE LD		

/ALVES & FITTINGS:

:l#	Description	Fric	Dia (inches)	(gpm)	Node->Node	(feet)
3	Standard elbow-90 degree CM2-1 LD	0.54	3.000			
5	Gate valve CM2-1 LD	0.14	3.000			
7	Standard Tee-thru flo CM2-2 LD	0.36	3.000			
9	Gate valve CM2-2 LD	0.14	3.000			
11	Standard Tee-thru flo CM2-3 LD	0.36	3.000			
13	Gate valve CM2-3 LD	0.14	3.000			
15	Standard Tee-thru flo 3" METER LD	0.36	3.000			
17	Gate valve 3' METER LD	0.14	3.000			
19	Exit UNIT 2 FM LD	1.00	3.000			

'UMPS (FVHs):

:l#	Flow inc (gpm)	Shut hd (feet)	2nd (feet)	3rd (feet)	4th (feet)
1 CM2-1 LD PUMP 2 HP	16.00	52	48	42	30
20 CM2-2 PUMP 2HP LD	16.00	52	48	42	30
22 CM2-3 PUMP 2HP LD	16.00	52	48	42	30

IODES:

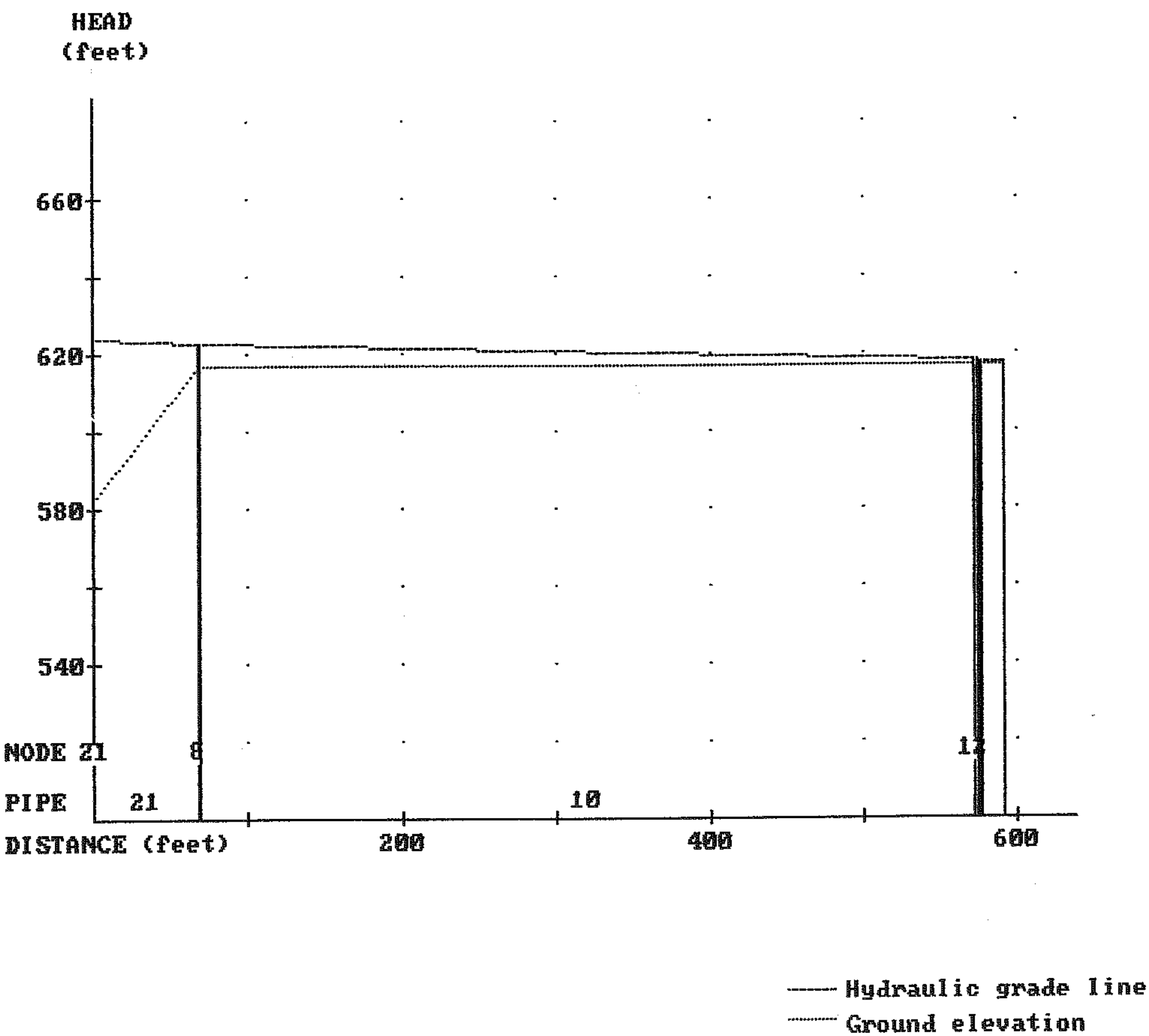
Iode#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)
1	579.50 CM2-1 LD	N/A	N/A	tbs	1.00
2	579.50 CM2-1 LD	N/A	N/A	0.00	tbs
3	616.50 CM2-1 LD	N/A	N/A	0.00	tbs
4	616.50 CM2-1 LD	N/A	N/A	0.00	tbs
5	616.50 CM2-1 LC	N/A	N/A	0.00	tbs
6	616.50 CM2-1 LD	N/A	N/A	0.00	tbs

Date: 8/21/101   4:19 pm

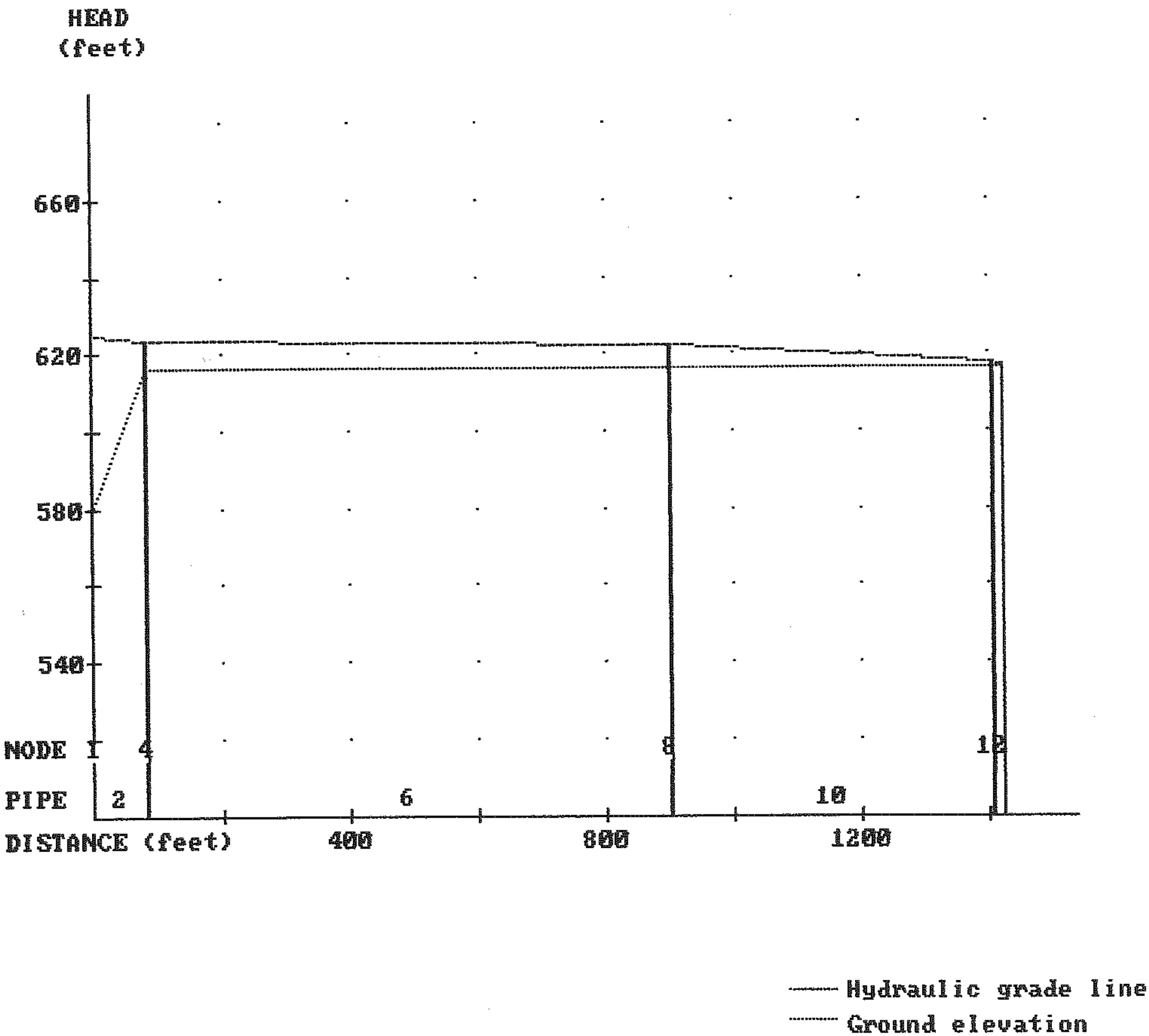
NODES: cont'd...

Node#	Elevation (feet)	X-coord (feet)	Y-coord (feet)	Demand (gpm)	Pressure (feet)
7	616.50	N/A	N/A	0.00	tbs
	CM2-2 LD				
8	616.50	N/A	N/A	0.00	tbs
	CM2-2 LD				
9	616.50	N/A	N/A	0.00	tbs
	CM2-2 LD				
10	616.50	N/A	N/A	0.00	tbs
	CM2-2 LD				
11	616.50	N/A	N/A	0.00	tbs
	CM2-3 LD				
12	616.50	N/A	N/A	0.00	tbs
	CM2-3 LD				
13	616.50	N/A	N/A	0.00	tbs
	CM2-3 LD				
14	616.50	N/A	N/A	0.00	tbs
	CM2-3 LD				
15	616.50	N/A	N/A	0.00	tbs
	3" METER LD				
	616.50	N/A	N/A	0.00	tbs
	3" METER LD				
17	616.50	N/A	N/A	0.00	tbs
	3" METER LD				
18	616.50	N/A	N/A	0.00	tbs
	3"METER LD				
19	616.50	N/A	N/A	0.00	tbs
	UNIT 2 FM LD				
20	616.50	N/A	N/A	tbs	0.00
	UNIT 2 FM LD				
21	581.50	N/A	N/A	tbs	1.00
	CM2-2 PUMP 2 HP LD				
22	581.50	N/A	N/A	0.00	tbs
	CM2-2 PUMP 2 HP LD				
23	583.50	N/A	N/A	tbs	1.00
	CM2-3 PUMP 2 HP LD				
24	583.50	N/A	N/A	0.00	tbs
	CM2-3 LD				

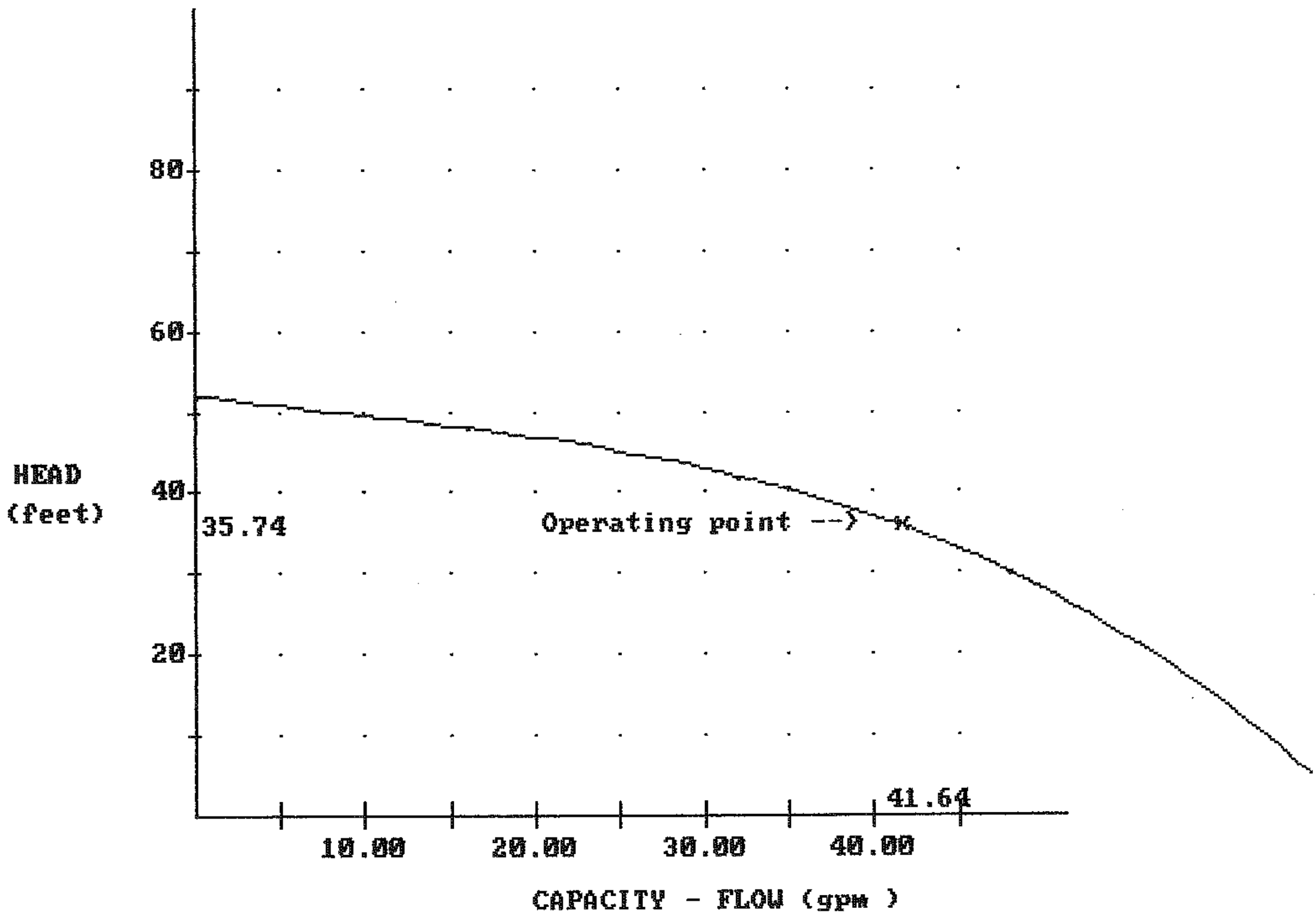
HGL for loop:2   System: CAMUZ_3D.NET -



HGL for loop:1   System: CAMU2_3D.NET -



PUMP #22 System: CAMU2_3D.NET -



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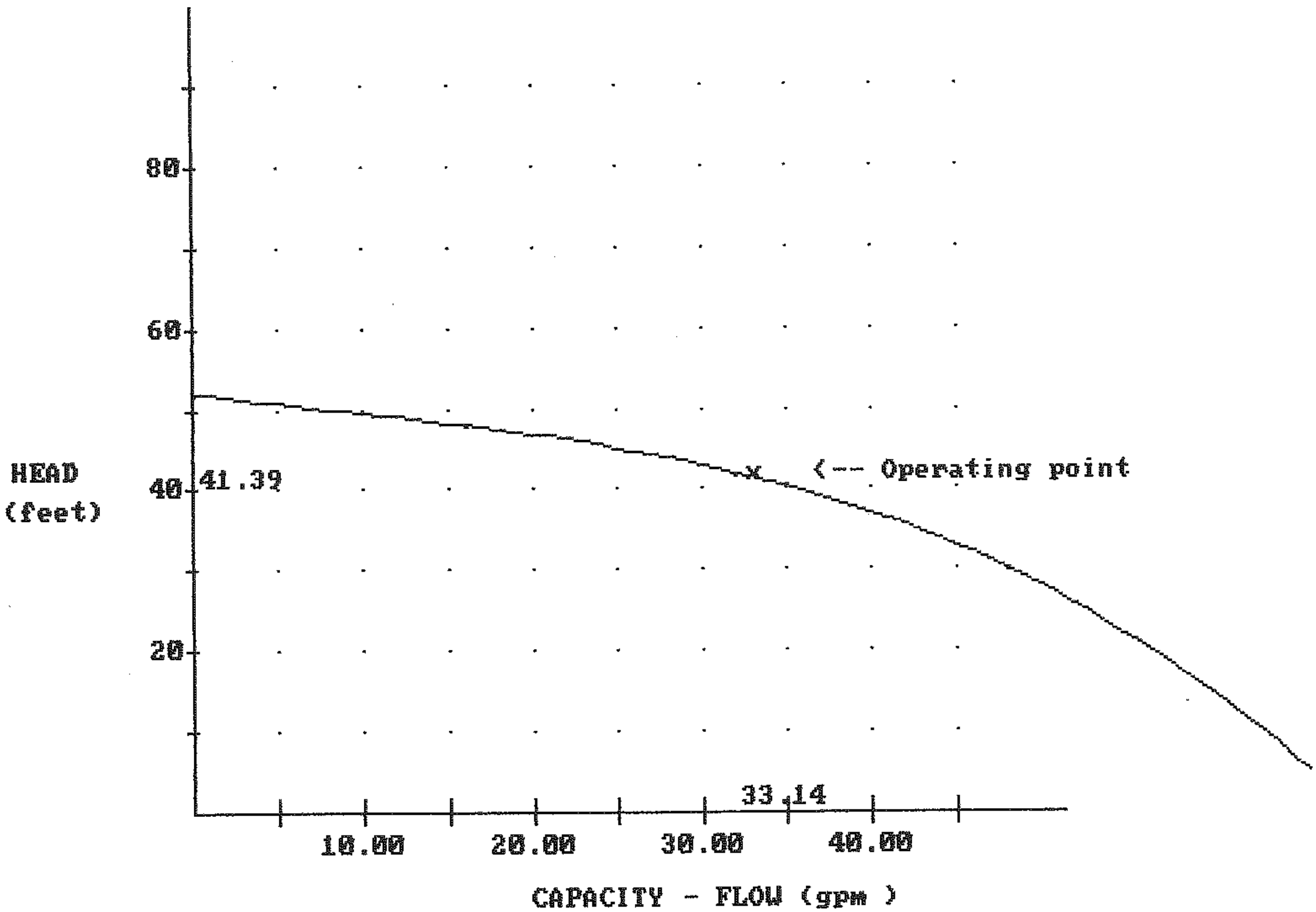
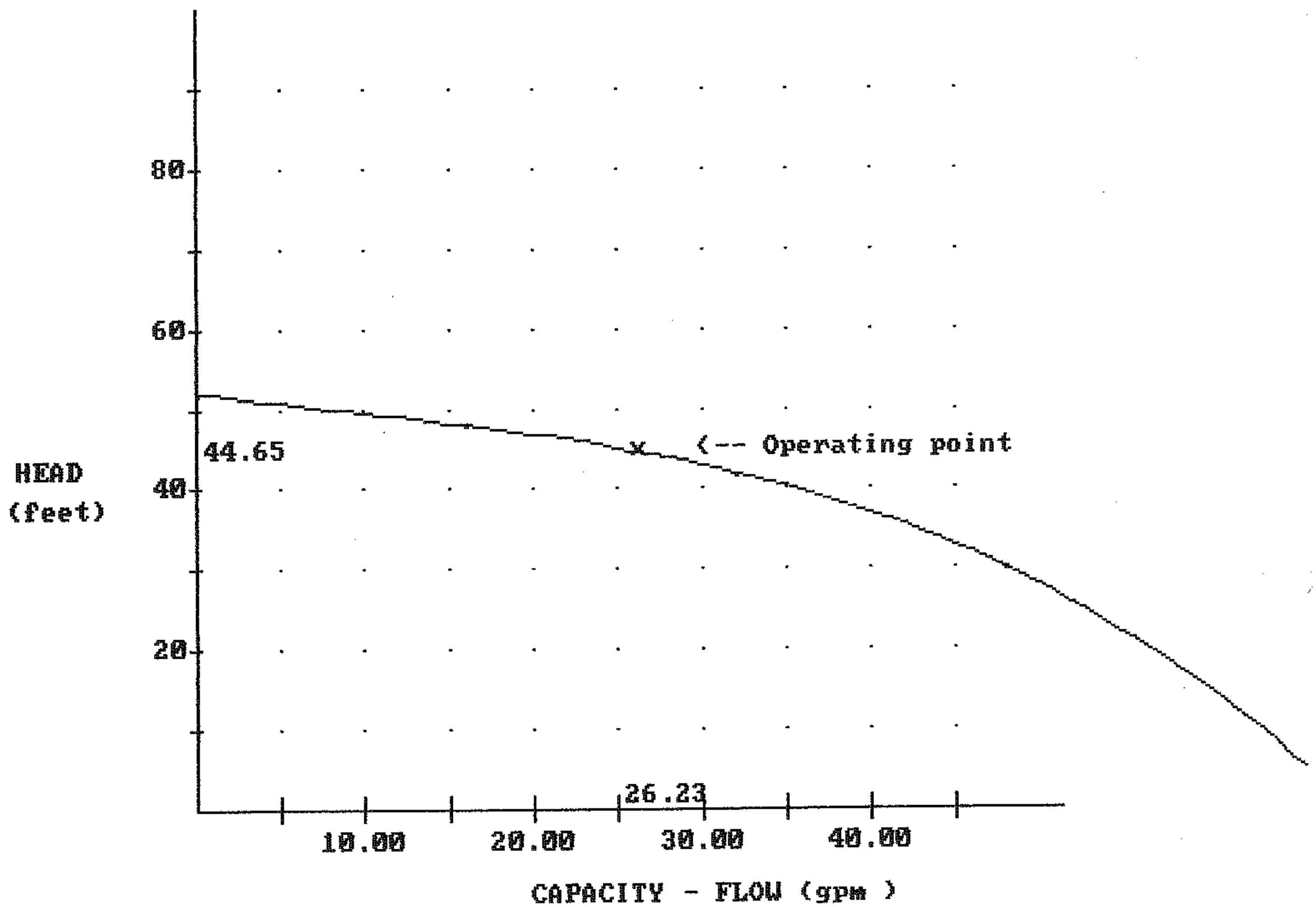


PUMP #1 System: CAMU2_3D.NET -



APPENDIX K6

RESPONSE ACTION PLAN

RESPONSE ACTION PLAN
CORRECTIVE ACTION MANAGEMENT UNIT
GRAND CALUMET RIVER SEDIMENT REMEDIATION PROJECT

Prepared for:

U.S. Steel – Gary Works
Gary, Indiana

Prepared by:

Earth Tech

August 2001

RESPONSE ACTION PLAN
CORRECTIVE ACTION MANAGEMENT UNIT
GRAND CALUMET RIVER SEDIMENT REMEDIATION PROJECT
U.S. STEEL – GARY WORKS

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1.0 INTRODUCTION

1.1 General

U.S. Steel plans to construct and operate a Corrective Action Management Unit (CAMU) on U.S. Steel property contiguous to its Gary Works facility in Gary, Indiana. The proposed facility is regulated under the Resource Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act (TSCA). The CAMU is an integral part of U.S. Steel's obligations for the Grand Calumet River Sediment Remediation Program. The Program includes the hydraulic dredging of contaminated, non-native sediments from approximately five miles of the Grand Calumet River adjacent to the Gary Works facility. The sediments will be conveyed via pipeline to the CAMU for passive dewatering and permanent disposal.

As part of the permit application for CAMU and as required by the U.S. Environmental Protection Agency (USEPA) 40 CFR Part 264, the operator or owner of a CAMU must have an approved Response Action Plan (RAP) before receipt of waste. The RAP is a site-specific plan that addresses leakage through the top liner into the secondary leachate collection system (SLCS) to assure that the liquids do not migrate out of the unit. The SLCS is also referred to as the leak detection system (LDS). The RAP establishes corrective action measures that are to be carried out when the leakage rate exceeds one of two trigger levels. The lower trigger leakage rate is the Response Rate (RR), which consists mainly of sources other than leachate. The higher trigger leakage rate is the Action Leakage Rate (ALR). The action leakage rate is the maximum design flow rate that the SLCS can remove without the fluid head on the bottom liner exceeding 1 foot. The ALR is a site-specific value based upon the capacity of the components of the site's SLCS. If the ALR is exceeded, the most intensive corrective action measures of the RAP are initiated. The Response Rate and the Action Leakage Rate are discussed in Section 3.0.

This RAP is a part of the CAMU's overall leachate management program. It develops site-specific performance characteristics for the primary leachate collection system (PLCS) and SLCS, and describes the proposed response actions to protect the environment from flow rate changes that potentially indicate unanticipated flows into the SLCS. This RAP includes (1) a description of the landfill unit; (2) a description of the sources of liquid that may be present in the SLCS; (3) the criteria that govern implementation of appropriate response; and (4) a proposed outline of the reporting procedures to state and federal agencies.

1.2 Project Description

The design basis for the CAMU is for containment of the non-native sediments to be dredged from Transects 1 through 36 of the Grand Calumet River. The CAMU consists of two Units: Unit 1 is for the TSCA and RCRA-regulated non-native dredge spoils from Transects 1 through 11 and Horizon 1 of Transect 17; and Unit 2 will hold the remaining dredge spoils (i.e. non-TSCA and non-hazardous) from Transects 12 through 36. Unit 1 is approximately 12.06 acres and Unit 2 is approximately 28.87 acres.

Both Units 1 & 2 have a primary leachate collection system (PLCS) and a secondary leachate collection system (SLCS) as illustrated in the design drawings. These systems are designed and managed to control and remove liquids in a manner consistent with USEPA's liquid management strategy. The components include primary and secondary leachate collection pipes, risers, sumps, cleanouts, forcemains and manholes. Unit 1 has two sumps and Unit 2 has three sumps. Sumps are located at low points in the units to collect the liquids that enter the leachate collection systems. Liquids will be removed from each PLCS at regular intervals by pumps placed inside sideslope risers. This will provide effective leachate management and will minimize the hydrostatic head on the lining systems. The performance of the primary liner and PLCS will be judged by regular documentation of the liquid volume encountered in and removed from the SLCS.

Both Units have been designed to meet or exceed EPA guidelines for landfills. The liner design components from top to bottom are as follows:

- Leachate collection system with granular drainage blanket, geotextile cushion, and piping on the base and geocomposite drainage layer on the sidewalls.

- Primary 60 mil HDPE geomembrane (smooth on base and textured on sideslopes)
- Secondary leachate collection system with geocomposite drainage layer and piping
- Secondary liner comprised of 60-mil HDPE geomembrane (smooth on base and textured on sideslopes) and underlying geosynthetic clay liner (GCL)

The base grades for both Units have been adjusted so that the bottom of the liner system will be above the high elevation of the groundwater table. To gain the dredge volume lost by keeping the liner system above the groundwater table, a 20-ft vertically high 1H:1V sideslope was designed along the perimeter sideslope of CAMU.

2.0 POTENTIAL SOURCES OF LIQUIDS IN THE SECONDARY LEACHATE COLLECTION SYSTEM

2.1 General

The purpose of this section is to: (1) establish the basis for the Response Rate (RR) and Action Leakage Rate (ALR) calculations described in Section 3.0 and (2) identify potential sources of liquids that could impact the quantity of liquid collected in the secondary leachate collection system (SLCS) sumps of each cell. Liquids entering an SLCS have been considered from three potential sources. These sources are: (1) construction liquids (including precipitation); (2) permeation and leakage of liquids through the primary liner; and (3) groundwater and other liquid sources located outside the secondary geomembrane permeating and leaking through the secondary composite liner system.

2.2 Construction Liquids

The term "construction liquids" is used in this RAP to identify liquids that have entered the CAMU during the SLCS construction period. Construction liquids include rainfall and snow melt (precipitation) and water used to adjust the moisture content of the material placed as part of the SLCS construction. Construction liquids will drain from the SLCS drainage layer under the force of gravity. Because the hydraulic conductivity of the drainage layer is 1×10^{-2} cm/sec, construction liquids will normally drain out of the SLCS within a few months following the completion of the primary leachate collection system (PLCS) construction. As such, the amount of liquid trapped in the system during construction has not been included in the calculation of the Response Rate. This is considered a conservative approach.

2.3 Permeation and Leakage through the Primary Liner System

Even when good construction practices and construction quality control and assurance procedures are followed, defects equivalent to numerous ¼-inch holes per acres in the geomembrane may be reasonably expected. Liquid migration through the primary base liner is expected to be relatively independent of single rainfall events, but it is expected to vary with seasonal rainfall. If liner defects are present, slight temporary increases in flow rates may develop after major storms since temporary ponding of surface water may result in higher flow into the PLCS and through defects in the sideslope liner into the SLCS. Depending on the amount of dredge disposed in the CAMU, increased flow could lag the rainfall event by several days or weeks.

Flows in the SLCS generally increase in the winter and spring due to more precipitation during these seasons. Higher flows in the PLCS cause higher heads in the primary liner system with a corresponding increase in flow to the SLCS due to permeation and leakage through the primary HDPE geomembrane. In addition, increased flows above the PLCS increase the probability of liquids coming in contact with a defect in the primary HDPE geomembrane, particularly on side slopes.

Fluid migration through the side slope liner will be relatively small due to the presence of a dredge deposit on the side slope in combination with the side slope geocomposite and the primary and secondary geomembranes. However, in connection with rainfall or snow melt events, significant liquid quantities could enter the SLCS if defects are present in the primary HDPE geomembrane on the perimeter side slope.

A HDPE geomembrane typically has permeability on the order of 2×10^{-11} cm/sec. Pinholes in the liner are typically limited to one ¼-in hole per acre. Coupled together, permeation and leakage through the primary liner is typically on the order of 1 gallon/acre-day. However, for the Response Rate (RR) calculation, a value of 20 gpad was selected in compliance with pertinent EPA guidelines. This accommodates uncertainties in numerical calculations (both assumptions and theory), potential leakage associated with unique design features (sumps), and potential liquid sources not accounted for in other quantified components of the RR.

2.4 <u>Liquids from Outside the Secondary HDPE Geomembrane</u>

The two potential outside sources of liquid considered are liquids resulting from consolidation of the

GCL and groundwater. Liquids from these sources enter the SLCS via permeation through the intact secondary HDPE geomembrane or leakage through local defects in the secondary HDPE geomembrane. However, these two potential sources of liquids in the SLCS are limited by the fact the base grades of the liner system have been adjusted to be above the highest seasonal groundwater table. The GCL has less of a chance to be saturated with groundwater, and as a result, there is less of a chance that permeation or leakage upward through the secondary geomembrane will occur.

Groundwater is usually considered to be the most predominant outside liquid source that may contribute to the liquid in the SLCS sumps. The groundwater table will vary seasonally during the CAMU operation and closure. Despite the fact that the base grades of the CAMU are above the groundwater table, it is still likely that groundwater will intrude into the SLCS sumps due to seasonal fluctuation. A conservative value of 10 gallons per acre per day is chosen.

3.0 RESPONSE ACTION TRIGGER LEVELS

3.1 Action Leakage Rate (ALR)

The EPA defines the Action Leakage Rate (ALR) as the maximum design flow rate that the secondary leachate collection system (SLCS) can remove without the fluid head on the bottom liner exceeding one foot. The ALR is the higher value of the two trigger levels. Therefore, the response actions are much more severe if the leakage rate through a sump exceeds the ALR. The ALR is a function of the flow capacity of the various components of the SLCS. These flow components include:

- Flow to the 18" Secondary Leachate Collection Riser through the Drainage Layer
- Flow through the Pipe Perforations of the SLCS Riser Pipe
- Flow through the SLCS at Entrance to Sump; which includes
  - Flow through the Geocomposite
  - Flow through the Secondary Leachate Collection Pipe
  - Flow through the Pipe Perforations of the Secondary Leachate Collection Pipe
  - Flow to the Collection Pipe through the Drainage Layer

The flow capacities of these components of the SLCS are calculated in Attachment A. It was determined that the flow through the drainage stone and the geocomposite governs the choice of the ALR, as it had the minimum flow capacity. The combined flow through the drainage stone and the geocomposite at the sump entrance is 70,925 gallons per day. A factor of safety of 2.0 has been included in the calculations. This will allow for uncertainties in the design (e.g. slope, hydraulic conductivity, thickness of drainage material), construction, operation, and location of the SLCS, waste and leachate characteristics, likelihood and amounts of other sources of liquids in the SLCS, and proposed response actions (e.g. the ALR must consider decreases in the flow capacity of the system over time resulting from siltation and clogging, rib layover and creep of synthetic components of the system, overburden pressure, etc.).

The ALR is determined by converting the minimum flow rate to a per unit acre basis. Dividing the flow rate (70,925 gallons per day) by the maximum drainage area to a sump will give the most conservative (i.e. lowest) estimate for the ALR. Unit 2 East 1 has the maximum drainage area at 12.10 acres. **Therefore, the selected unit-specific action leakage rate for the CAMU is 5,862 gallons/acre-day.** The results are tabulated in Table 1.

The action leakage rate of 5,862 gallons/acre-day is termed "unit-specific" because it is based on a unit area (i.e. one acre). The selected "unit-specific" ALR is converted to a selected "sump-specific" ALR by multiplying it by the drainage area to each sump. These calculations are also included in Table 1.

Sumps should be monitored at least once a week. If liquids are present, they should be pumped out and the data recorded. The flow rate between two pumping events should be converted to an average daily flow rate for each sump. The flow rate is then compared to the "unit-specific" ALR or the "sump-specific" ALR, depending on the units involved. If the flow rate for a sump exceeds the ALR, the appropriate response actions are carried out.

3.2 Response Rate (RR)

The Response Rate (RR) is the lower of the two trigger levels. It sets the lowest leakage rate at which response action besides monitoring is required. Liquids that are included in the RR consist mainly of sources other than leachate. The long-term sources of liquids in the RR calculation include (1) liquids resulting from permeation and leakage through the primary liner and (2) liquids from groundwater permeating through the secondary HDPE geomembrane and leaking through small defects in the secondary HDPE geomembrane.

In the case of liquids through the primary liner, it was determined in Section 2.3 that it would be minimal due to the low permeability and small amount of defects in the liner. A conservative value of 20 gpad was selected according to EPA guidelines to account for uncertainties in calculations, potential leakage associated with unique design features and potential liquid sources not accounted for in other components of the RR.

In the case of liquids through the secondary liner from consolidation of the GCL and groundwater, it was also determined to be minimal due to the fact that the base grades have been designed to be above the highest seasonal groundwater. In Section 2.4, a conservative value of 10 gpad was chosen to account for seasonal fluctuations in the GW table.

Adding the two potential sources of liquids, the selected "unit-specific" Response Rate (RR) is **30 gallons/acre-day**. As with the ALR calculation, the selected "unit-specific" RR is converted to a selected "sump-specific" RR by multiplying it by the drainage area to each sump. These calculations are included in Table 2.

4.0 RESPONSE ACTIONS

4.1 General

The response actions that are required to respond to various flow rates in the secondary leachate collection system (SLCS) sumps are provided in this section. As discussed in Section 3.0, a Response Rate (RR) of **30 gallons/acre-day** and an Action Leakage Rate (ALR) of **5,862 gallons/acre-day** have been selected. These trigger levels apply to each individual sump. For all flow rates the following procedure is required for monitoring of the SLCS:

- Each SLCS sump will be monitored at least once every 7 days for the presence of liquids. Liquids that can be pumped out the sump will be removed and the quantity measured and recorded. If the sump is monitored more frequently, or if liquids are removed more frequently, the inflow will be determined for each pumping event. The inflow value will be calculated by adding the liquid volumes removed within the time interval between pumping events and dividing that sum by the number of days between pumping events. The pumped amount of liquid will be divided by the days since the previous pumping event to establish a daily average inflow. However, the inflow value compared against the trigger levels outlined in this RAP will be the weekly average value.

4.2 Flow Rates at or below the Response Rate

Routine monitoring should continue. No action is required.

4.3 Flow Rates between the Response Rate and the Action Leakage Rate

The following response actions will be carried out:

1. Verbally notify the INDEM within three working days if the average flow to an SLCS sump for two consecutive pumping events exceeds the RR, if not clearly attributable to an operational

disturbance (e.g. equipment or power failures). Also, perform the following:

a) Conduct a review of the most recent SLCS and PLCS analytical data available from the sampling program required by the site permit.

b) Immediately perform the following tests and observations on samples of the SLCS and PLCS liquids:

- Color
- Turbidity
- Specific conductance
- pH

Make a preliminary comparison of these values with the previous results and record the information.

c) Within a week after the two RR exceedances, perform the sampling and analysis of the SLCS liquid that would normally occur on a quarterly basis. Test results are to be available within forty-five (45) days of the exceedance. Results will be reviewed with the INDEM to determine what, if any, additional response actions are necessary. This sampling will satisfy the next quarterly sampling requirement for that sump.

d) Increase monitoring and pumping frequency of the SLCS sump of the unit involved, if pumpable quantities are present, to every day until flow decreases below the RR. Also, verify that the automatic removal of liquid from the PLCS is occurring as designed. If the automatic pumping of the PLCS is unable to maintain a level of 12 inches or less in the PLCS, evaluate whether increasing the pumping rate and prioritization of the unit is needed.

e) Review all analytical data and investigate alternative sources of liquid.

2. If the flow is between the RR and the ALR for seven consecutive additional daily pumping events, provide written notification to the INDEM within 14 days and implement the following steps:

   a) Remove all standing water from within the unit.

   b) Assess the potential cause(s) of the RR exceedance. Examine any exposed portions of the unit's liner.

   c) Repair any observed damage.

d) If no obvious defects are detected, propose actions that would return the leakage rate to below the RR. Upon approval, sequentially inspect side slope liner and possible leakage locations of base liner if necessary, removing waste as needed. Repair any observed damage.

e) Document location, type and extent of liner damage if any was detected.

3. If the leakage rate cannot be returned and maintained below the RR after all feasible measures have been taken, then automatic pumping and volume measurement of the secondary collection system must be instituted.

4.4 Flow Rates greater than the Action Leakage Rate

To determine if the action leakage rate has been exceeded the owner or operator must convert the weekly flow rate from the monitoring data to an average daily flow rate (gallons per acre per day) for each sump. If the flow rate for a sump exceeds the action leakage rate of 5,862 gallons/acre-day, the following response measures will be carried out in that sump area:

1. Notify in writing the USEPA and INDEM within seven (7) working days if the average flow to an SCLS pump for one pumping event exceeds the ALR, if it is not clearly attributable to an operational disturbance. Determine the need to temporarily stop placing sediment into the affected CAMU during the CAMU's normal operation, except if the ALR value is exceeded within the first thirty (30) days of operation or during post-closure construction when flows are not truly representative. If the ALR value is exceeded after the first 30 days of unit operation, determine if sediment placement in the unit should cease until repairs to the lining system or other appropriate actions are completed, and flows to the SLCS sumps have decreased to below the ALR. Prepare a written preliminary assessment report describing the amount of liquids, possible location, size and cause of any leaks, and short-term actions taken and planned. Submit this report to USEPA and INDEM within 14 days of ALR exceedance. Sediment placement may not resume in the unit until written notification is given by INDEM.

2. Increase monitoring and pumping frequency from the SCLS sump of the unit involved, if pumpable quantities are present, to once every day until flow decreases below the ALR. Also, verify that the automatic removal of liquid from the PLCS sumps is occurring as designed.

3. Perform the following tests and observations on samples of the SCLS and PLCS liquids:
   - Color
   - Turbidity
   - Specific conductance
   - pH

   Make a preliminary comparison of these values with previous results and record the information.

4. If possible, determine the location, size and cause of any leak.

5. Determine other short-term and long-term actions to be taken to mitigate or stop any leaks.

6. Within thirty (30) days after the first notification that the ALR has been exceeded, submit to the USEPA and INDEP the results of the analyses of responses 1 through 5 above, as well as the results of actions taken and planned.

7. If the average flow exceeds the ALR for two consecutive pumping events, implement the following steps:
   a) Test a sample of the liquid obtained from the SLCS for constituents listed in Table 3,
   b) Remove all standing water inside the unit,
   c) Examine any exposed portion of the unit liner, and
   d) Repair any observed damage.

8. If flow continues to exceed the ALR for two additional pumping events, provide third party inspection by a registered professional engineer. The engineer shall investigate alternative sources of liquids, review available analytical and pumping event data for the unit to identify any trends or

relationships, and prepare a written report for the USEPA and INDEM on the findings and recommended actions to protect human health and the environment. The Groundwater Monitoring Plan will also be evaluated to determine if supplemental response actions are necessary.

9. As long as the flow rate in the SLCS exceeds the ALR, submit monthly reports to the USEPA and INDEM summarizing actions taken and planned.

10. If the ALR continues to be exceeded after taking all reasonable corrective measures, closure of the affected unit shall be considered.

TABLES

TABLE 1

ACTION LEAKAGE RATE (ALR) SUMMARY

CORRECTIVE ACTION MANAGEMENT UNIT
GRAND CALUMET RIVER SEDIMENT REMEDIATION PROJECT
U.S. STEEL GARY WORKS

(1) Leak Detection Sump Designation	(2) Location	(3) Calculated Sump-Specific Limiting Flow Rate (gallons/day)	(4) Drainage Area (acres)	(5) = (3) / (4) Corresponding Unit-Specific Limiting Flow Rate (gallons/acre-day)	(6) = minimum(5) Selected Unit-Specific ALR (gallons/acre-day)	(7) = (4) x (6) Selected Sump-Specific ALR (gallons/day)
DS1-2	Unit 1 West	70,925	5.85	12,124	5,862	34,290
DS1-1	Unit 1 South	70,925	6.21	11,421	5,862	36,400
DS2-3	Unit 2 East 1	70,925	12.10	5,862	5,862	70,925
DS2-2	Unit 2 East 2	70,925	7.81	9,081	5,862	45,779
DS2-1	Unit 2 South	70,925	8.96	7,916	5,862	52,520

Notes

1. Unit 2 East 1 is north of Unit 2 East 2.
2. Column 3 is taken from Attachment A of this Response Action Plan.

TABLE 2

RESPONSE RATE (RR) SUMMARY

CORRECTIVE ACTION MANAGEMENT UNIT
GRAND CALUMET RIVER SEDIMENT REMEDIATION PROJECT
U.S. STEEL GARY WORKS

(1) Leak Detection Sump Designation	(2) Location	(3) Selected Unit-Specific RR (gallons/acre-day)	(4) Drainage Area (acres)	(5) = (3) X (4) Selected Sump-Specific RR (gallons/day)
DS1-2	Unit 1 West	30	5.85	175.5
DS1-1	Unit 1 South	30	6.21	186.3
DS2-3	Unit 2 East 1	30	12.10	363.0
DS2-2	Unit 2 East 2	30	7.81	234.3
DS2-1	Unit 2 South	30	8.96	268.8

Notes
1. Unit 2 East 1 is north of Unit 2 East 2.

TABLE 3

PRIORITY POLLUTANTS TO BE ANALYZED
IF THE ACTION LEAKAGE RATE IS EXCEEDED

NDPES NO.	COMPOUND
ACIDS	
1A	2-Chlorophenol
2A	2,4-Dichlorophenol
3A	2,4-Dimethylphenol
4A	4,6-Dinitro-o-cresol
5A	2,4-Dinitrophenol
6A	2-Nitrophenol
7A	4-Nitrophenol
8A	p-Chloro-m-cresol
9A	Pentachlorophenol
10A	Phenol
11A	2,4,6-Trichlorophenol
BASES/NEUTRALS	
1B	Acenaphthene
2B	Acenaphtylene
3B	Anthracene
4B	Benzidine
5B	Benzo (a) anthracene
6B	Benzo (a) pyrene
7B	Benzo (b) fluoranthene
8B	Benzo (ghi) perylene
9B	Benzo (k) fluoranthene
10B	bis (2-Chloroethoxy) methane
11B	bis (2-Chloroethyl) ether
12B	bis (2-Chloroisopropyl) ether
13B	bis (2-Ethylhexyl) phthalate
14B	4-Bromophenyl phenyl ether
15B	Butyl benzyl phthalate
16B	2-Chlornaphthalene
17B	4-Chlorophenyl phenyl ether
18B	Chrysene
19B	Dibenzo (a,h) anthracene
20B	1,2-Dichlorobenzene
21B	1,3-Dichlorobenzene
22B	1,4-Dichlorobenzene
23B	3,3-Dichlorobenzidine
24B	Diethyl phthalate
25B	Dimethyl phthalate
26B	Di-n-butyl phthalate
27B	2,4-Dinitrotoluene

NPDES NO.	COMPOUND
BASES/NEUTRALS (CONTINUED)	
28B	2,6-Dinitrotoluene
29B	Di-n-octyl phthalate
30B	1,2-Diphenylhydrazine
31B	Fluoranthene
32B	Fluorene
33B	Hexachlorobenzene
34B	Hexachlorobutadiene
35B	Hexachlorocyclopentadiene
36B	Hexachloroethane
37B	Indeno (1,2,3-c,d) pyrene
38B	Isophorone
39B	Naphthalene
40B	Nitrobenzene
41B	N-Nitrosodimethylamine
42B	N-Nitrosodi-n-propylamine
43B	N-Nitrosodiphenylamine
44B	Phenanthrene
45B	Pyrene
46B	1,2,4-Trichlorobenzene

METALS (TOTAL)

Antimony
Arsenic
Beryllium
Cadmium
Chromium
Copper
Lead
Mercury
Nickel
Selenium
Silver
Thallium
Zinc

TABLE 3
(continued)

PRIORITY POLLUTANTS TO BE ANALYZED IF THE ACTION LEAKAGE RATE IS EXCEEDED

NDPES NO.	COMPOUND
PESTICIDES	
1P	Aldrin
2P	Alpha-BHC
3P	Beta-BHC
4P	Gamma-BHC
5P	Delta-BHC
6P	Chlordane
7P	4,4'-DDT
8P	4,4'-DDE
9P	4,4'-DDD
10P	Dieldrin
11P	Endosulfan I
12P	Endosulfan II
13P	Ensosulfan sulfate
14P	Endrin
15P	Endrin aldehyde
16P	Heptachlor
17P	Heptachlor epoxide
18P	PCB-1242
19P	PCB-1254
20P	PCB-1221
21P	PCB-1232
22P	PCB-1248
23P	PCB-1260
24P	PCB-1016
VOLATILES	
3V	Benzene
5V	Bromoform
6V	Carbon tetrachloride
7V	Chlorobenzene
8V	Chlorodibromethane
9V	Chloroethane

NPDES NO.	COMPOUND
VOLATILES (CONTINUED)	
10V	2-Chloroethylvinyl ether
11V	Chloroform
12V	Dichlorobromomethane
14V	1,1-Dichloroethane
15V	1,2-Dichloroethane
16V	1,1-Dichloroethylene
17V	1,2-Dichloropropane
18V	cis-1,3-Dichloropropylene
19V	•Ethylbenzene
20V	Methyl bromide
21V	Methyl chloride
22V	Methylene chloride
23V	1,1,2,2-Tetrachloroethane
24V	Tetrachloroethylene
25V	Toluene
26V	1,2-Trans-dichloroethylene
27V	1,1,1-Trichloroethane
28V	1,1,2-Trichloroethane
29V	Trichloroethylene
31V	Vinyl chloride
18V	trans-1,3-Dichloropropylene

ATTACHMENT A

ACTION LEAKAGE RATE CALCULATIONS

CLIENT: U.S. Steel – Gary Works	**SUBJECT:** Corrective Action Management Unit (CAMU) Action Leakage Rate (ALR)	**Prepared By** TW	**Date** 07/23/01
PROJECT: Grand Calumet River Sediment Remediation		**Reviewed By** [illegible]	**Date** 8/28/01
		Approved By KM	**Date** 08/20/01

TASK

Determine flow capacity of various secondary leachate collection system (SLCS) componenets of the CAMU in order to determine the action leakage rate (ALR).

REFERENCES

1. Construction/Operation Level Design Report, CAMU, Calumet River Sediment Remediation Project, prepared by Montgomery Watson, dated January 2000.

2. ASTM D-4716 Transmissivity Test Results for Tex-Net TN3002/1125 geocomposite, performed by J&L Testing Company for U.S. Steel Gary, IN, Grand Calumet River - CAMU Project.

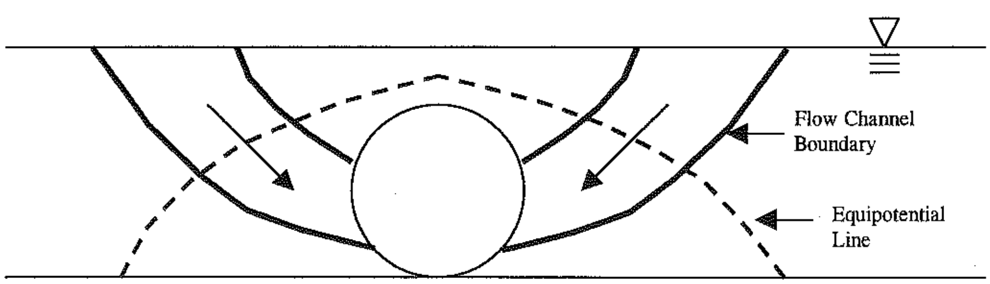
ASSUMPTIONS

1. In determining the action leakage rate (ALR), a factor of safety of 2.0 will be applied. This will account for uncertainties in the design (e.g. slope, hydraulic conductivity, thickness of drainage material), construction, operation, and location of the leak detection system (LDS), waste and leachate characteristics, and likelihood and amounts of other sources of liquids in the LDS. The ALR will also consider decreases in the flow capacity of the system over time resulting from siltation and clogging, rib layover and creep of synthetic components of the system overburden pressures, etc.

CALCULATIONS

1. Flow to the 18" Secondary Leachate Collection Riser through the Drainage Layer

The flow to the pipe can be estimated by drawing a flow net.



The flow is calculated by using Darcy's Law for flow nets.

$Q_{act} \quad = \quad kh_L(N_f/N_d)L$

Where

$k \quad = \quad$ hydraulic conductivity of the drainage medium

h_L = head loss
N_f = number of flow channels in the flow net = 3
N_d = number of potential drops across each flow channel = 2
L = length of the perforated section of the 18" riser pipe

Assumptions

- Pipe and pump capacity are greater than flow that will reach the pipe through the drainage material.
- Conditions within the drain remain saturated.
- INDOT coarse aggregate #5 has a hydraulic conductivity of 2.2 cm/sec.
- The maximum head is equal to the drain thickness; the average head on all sumps is assumed to be 2.0 ft.
- The length of the section of pipe with perforations is approximately 4 feet upslope in the sump.

Q_{act} = $kh_L(N_f/N_d)L$
= (2.2 cm/sec)(2 ft)(3/2)(4 ft)(1 in/2.54 cm)(1 ft/12 in)(86,400 sec/1 day)(7.48 gal/cf)
= 559,763 gpd

Apply the factor of safety to get the allowable flow.

Q_{allow} = Q_{act} / FS
= 559,763 gpd / 2
= 279,882 gpd

2. Capacity through the Pipe Perforations of the Secondary Leachate Riser Pipe

The flow through the pipe perforations can be estimated using the Bernoulli orifice equation.

Q_{act} = $CA(2gh)^{1/2}$

Where

C = contraction and energy loss coefficient
A = effective orifice area
g = acceleration due to gravity = 32.2 ft/s^2
H = orifice head

Assumptions

- Free flow occur through the holes
- The head is constant and equal to the maximum depth of drain in the unit, which is assumed to be 1 foot (This is conservative when calculating the "minimum" ALR).
- The perforations have sharp edges; C = 0.61.
- There are the 22 - 1/2 in diameter holes per foot on the perforated section of the 18" leak detection riser pipe. The length of the section of pipe with perforations is approximately 4 feet upslope in the sump.

The effective orifice area can be calculated

A = (area of one hole) x (# of holes per ft) x (length of perforated section of riser pipe)
= (d²/4)(22 holes/ft)(4 ft)
= [(0.5 in x 1 ft/12 in)² / 4](22 holes/ft)(4 ft)
= 0.12 sf

Q_{act} = $CA(2gh)^{1/2}$
= $0.61(0.12\ sf)(2 \times 32.2\ ft/s^2 \times 1\ ft)^{1/2}(86{,}400\ sec/1\ day)(7.48\ gal/cf)$
= 379,638 gpd

Apply the factor of safety to get the allowable flow.

Q_{allow} = Q_{act} / FS
= 379,638 gpd / 2
= 189,919 gpd

3. Capacity through the secondary leachate collection system at entrance to sump

A. Capacity through the geocomposite

The flow can be calculated by converting Darcy's Law to include the transmissivity of the geocomposite.

Q = kiA
Q = ki(t x W)
Q/W = i(k x t)
Q/W = i
Q = i W

Where

Q = flow rate
k = permeability (hydraulic conductivity) in the plane of the geocomposite
i = hydraulic gradient
A = cross-sectional flow area
t = thickness of the geocomposite
W = width of the geocomposite
= transmissivity of the geocomposite

Assumptions

- The slope is 1.0% to the edge of the sump.
- From Appendix J1 of Reference 1, the maximum normal load that the geocomposite will be subject to during operation of the impoundment is 3,010 psf. From Reference 2, transmissivity tests were performed on a Tex-Net TN3002/1125 geocomposite at loads of 6,000 psf, 12,000 psf and 24,000 psf. The testing at 6,000 psf is applicable. At a gradient of 0.01 under a loading of 6,000 psf, the transmissivity was 5.99 gal/min/ft.

Typical Leak Detection Sump Parameters:

Length = 13 ft (Drawing D27)
Width = 16.5 ft (Drawing D27)
Total Perimeter = 2(13 ft) + 2(16.5 ft) = 59 ft

Q_{ult} = i W
= (0.01 ft/ft)(5.99 gal/min/ft)(59 ft)(1440 min/day)
= 5,089 gpd

Apply the factor of safety to get the allowable flow.

Q_{allow} = Q_{act} / FS
= 5,089 gpd / 2
= 2,545 gpd

B. Capacity through the Secondary Leachate Collection Header Pipe

The capacity of the 6" perforated Schedule 120 Perforated PVC pipe can be determined by the Manning's equation.

$$Q = (1.49/n)\ A\ R^{2/3}\ S^{1/2}$$

Where,

n = Manning's roughness coefficient = 0.012 for PVC pipe

A = cross-section area of pipe
For 6" Schedule 120 PVC pipe, inner diameter is 5.434 in
A = (/4)(5.434 in x 1 ft/12 in)^2
= 0.161 sf

R = hydraulic diameter = diameter/4 for full flowing pipes
= (5.434 in x 1ft/12 in) / 4
= 0.1132 ft

S = pipe slope = 0.5% = 0.005 ft/ft

Q_{pipe} = (1.49 / 0.012) (0.161) (0.1132)$^{2/3}$ (0.005)^{½}
= 0.3304 cfs
= 213,528 gpd

C. Capacity through the Pipe Perforations of the 6" Secondary Leachate Collection Pipe

The flow through the pipe perforations can be estimated using the Bernoulli orifice equation.

<u>Assumptions</u>

- Free flow occur through the holes

- The maximum head above the pipe invert is 1.0 ft.
- The perforations have sharp edges; C = 0.61.
- From Detail 1/24 of Drawing D24, the perforated collection pipe will have two 3/8-in. diameter drill holes on the bottom of the pipe set 60° from center and spaced 5 in. on center from the next pair of holes. There are 6 holes per foot.
- From Drawing D7, the minimum length of collection pipe is a 430-ft length draining into the southernmost sump in Unit 2.

The effective orifice area can be calculated

$$
\begin{aligned}
A &= \text{(area of one hole) x (\# of holes per ft) x (length of perforated section of riser pipe)} \\
&= (d^2/4)(6 \text{ holes/ft})(430 \text{ ft}) \\
&= [\ (0.375 \text{ in x } 1 \text{ ft}/12 \text{ in})^2 / 4](6 \text{ holes/ft})(430 \text{ ft}) \\
&= 1.9788 \text{ sf}
\end{aligned}
$$

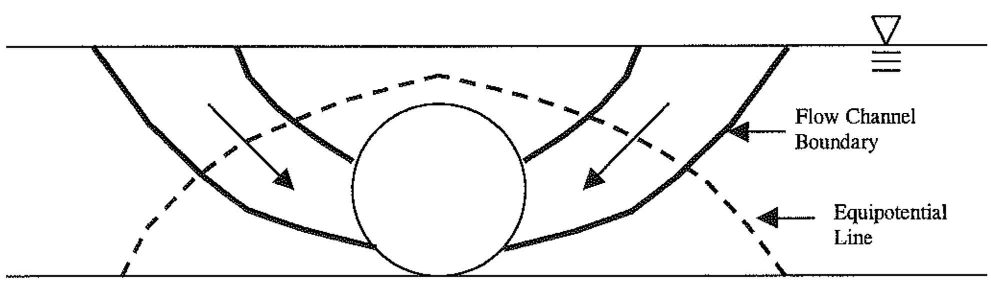
$$
\begin{aligned}
Q_{act} &= CA(2gh)^{1/2} \\
&= 0.61(1.9788 \text{ sf})(2 \text{ x } 32.2 \text{ ft/s}^2 \text{ x } 1 \text{ ft})^{1/2}(86{,}400 \text{ sec/1 day})(7.48 \text{ gal/cf}) \\
&= 6{,}260{,}226 \text{ gpd}
\end{aligned}
$$

Apply the factor of safety to get the allowable flow.

$$
\begin{aligned}
Q_{allow} &= Q_{act} / FS \\
&= 6{,}260{,}226 \text{ gpd} / 2 \\
&= 3{,}130{,}113 \text{ gpd}
\end{aligned}
$$

D. Flow to the 6" Secondary Leachate Collection Header Pipe through the Drainage Layer

The flow to the pipe can be estimated by drawing a flow net.



The flow is calculated by using Darcy's Law for flow nets.

$$Q_{act} = kh_L(N_f/N_d)L$$

Where

k	=	hydraulic conductivity of the drainage medium
h_L	=	head loss
N_f	=	number of flow channels in the flow net = 3
N_d	=	number of potential drops across each flow channel = 2
L	=	length of the perforated section of the 6" secondary leachate collection pipe

Assumptions

- Pipe and pump capacity are greater than flow that will reach the pipe through the drainage material.
- Conditions within the drain remain saturated.
- INDOT coarse aggregate #12 has a hydraulic conductivity of 1×10^{-2} cm/sec.
- The maximum head is equal to the drain thickness, which is 1.0 ft.
- The minimum length of collection pipe with perforations is 430 ft.

$$Q_{act} = kh_L(N_f/N_d)L$$
$$= (1 \times 10^{-2}\text{ cm/sec})(1\text{ ft})(3/2)(430\text{ ft})(1\text{ in}/2.54\text{ cm})(1\text{ ft}/12\text{ in})(86{,}400\text{ sec}/1\text{ day})(7.48\text{ gal/cf})$$
$$= 136{,}760\text{ gpd}$$

Apply the factor of safety to get the allowable flow.

$$Q_{allow} = Q_{act} / FS$$
$$= 136{,}760\text{ gpd} / 2$$
$$= 68{,}380\text{ gpd}$$

SUMMARY

The action leakage rate is the lowest capacity among the components of the secondary leachate collection system. Considering the flow through the secondary leachate collection header pipe, flow through the drainage stone governs. Therefore, the maximum flow is the amount through the drainage stone.

Q_{stone} = 68,380 gpd (from Item 3D)
$Q_{geocomposite}$ = 2,545 gpd (from Item 3A)

The combined flow through the drainage stone and the geocomposite at the sump entrance is

$$Q_{sump\ entrance} = 68{,}380\text{ gpd} + 2{,}545\text{ gpd}$$
$$= 70{,}925\text{ gpd}$$

Therefore,

$$\mathbf{Q_{ult} = 70{,}925\text{ gpd}}$$

Appendix M

APPENDIX M

HELP MODEL ANALYSES FOR INFILTRATION OF STORMWATER

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                  **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELPMO~1\usspre.D4
TEMPERATURE DATA FILE:       C:\HELPMO~1\usstem.D7
SOLAR RADIATION DATA FILE:   C:\HELPMO~1\ussrad.D13
EVAPOTRANSPIRATION DATA:     C:\HELPMO~1\usstra.D11
SOIL AND DESIGN DATA FILE:   C:\HELPMO~1\ussdes.D10
OUTPUT DATA FILE:            C:\HELPMO~1\ussout1.OUT


TIME:  12:56     DATE:   7/ 9/2001


******************************************************************************

    TITLE:  U.S. Steel - Gary Works - CAMU Berm Infiltration Analysis

******************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                      TYPE 2 - LATERAL DRAINAGE LAYER
                        MATERIAL TEXTURE NUMBER   1
         THICKNESS                  =       6.00   INCHES
         POROSITY                   =       0.4170 VOL/VOL
         FIELD CAPACITY             =       0.0450 VOL/VOL
         WILTING POINT              =       0.0180 VOL/VOL
         INITIAL SOIL WATER CONTENT =       0.1879 VOL/VOL
         EFFECTIVE SAT. HYD. COND.  =  0.999999978000E-02 CM/SEC
         SLOPE                      =       2.00   PERCENT
         DRAINAGE LENGTH            =      20.0    FEET
```

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 1.80
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	216.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1050 VOL/VOL
WILTING POINT	=	0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1077 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000002000E-02 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-SPECIFIED CURVE NUMBER OF 91.0, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 20. FEET.

SCS RUNOFF CURVE NUMBER	=	92.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.009	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.128	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.502	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.108	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	32.068	INCHES
TOTAL INITIAL WATER	=	32.068	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	117
END OF GROWING SEASON (JULIAN DATE)	=	290
AVERAGE ANNUAL WIND SPEED	=	10.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.60	1.31	2.59	3.66	3.15	4.08
3.63	3.53	3.35	2.28	2.06	2.10

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CHICAGO ILLINOIS

STATION LATITUDE = 41.78 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT

PRECIPITATION	30.45	994.802	100.00
RUNOFF	3.010	98.325	9.88
EVAPOTRANSPIRATION	22.506	735.269	73.91
DRAINAGE COLLECTED FROM LAYER 1	4.3080	140.742	14.15
PERC./LEAKAGE THROUGH LAYER 2	0.628763	20.542	2.06
AVG. HEAD ON TOP OF LAYER 2	0.3789		
PERC./LEAKAGE THROUGH LAYER 3	0.014218	0.465	0.05
CHANGE IN WATER STORAGE	0.612	20.001	2.01
SOIL WATER AT START OF YEAR	32.068	1047.657	
SOIL WATER AT END OF YEAR	32.680	1067.658	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.90	1172.853	100.00
RUNOFF	5.880	192.087	16.38
EVAPOTRANSPIRATION	21.120	689.980	58.83
DRAINAGE COLLECTED FROM LAYER 1	5.9345	193.880	16.53
PERC./LEAKAGE THROUGH LAYER 2	0.596636	19.492	1.66
AVG. HEAD ON TOP OF LAYER 2	0.4455		
PERC./LEAKAGE THROUGH LAYER 3	0.016768	0.548	0.05
CHANGE IN WATER STORAGE	2.949	96.359	8.22
SOIL WATER AT START OF YEAR	32.680	1067.658	
SOIL WATER AT END OF YEAR	32.720	1068.970	

SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	2.909	95.046	8.10
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.40	1450.547	100.00
RUNOFF	13.273	433.621	29.89
EVAPOTRANSPIRATION	26.993	881.854	60.79
DRAINAGE COLLECTED FROM LAYER 1	5.7482	187.793	12.95
PERC./LEAKAGE THROUGH LAYER 2	0.527584	17.236	1.19
AVG. HEAD ON TOP OF LAYER 2	0.4464		
PERC./LEAKAGE THROUGH LAYER 3	0.014559	0.476	0.03
CHANGE IN WATER STORAGE	-1.628	-53.196	-3.67
SOIL WATER AT START OF YEAR	32.720	1068.970	
SOIL WATER AT END OF YEAR	33.747	1102.516	
SNOW WATER AT START OF YEAR	2.909	95.046	6.55
SNOW WATER AT END OF YEAR	0.254	8.305	0.57
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.12	984.020	100.00
RUNOFF	5.806	189.672	19.28

EVAPOTRANSPIRATION	22.006	718.945	73.06
DRAINAGE COLLECTED FROM LAYER 1	2.4196	79.049	8.03
PERC./LEAKAGE THROUGH LAYER 2	0.393539	12.857	1.31
AVG. HEAD ON TOP OF LAYER 2	0.2148		
PERC./LEAKAGE THROUGH LAYER 3	0.014137	0.462	0.05
CHANGE IN WATER STORAGE	-0.126	-4.106	-0.42
SOIL WATER AT START OF YEAR	33.747	1102.516	
SOIL WATER AT END OF YEAR	33.876	1106.714	
SNOW WATER AT START OF YEAR	0.254	8.305	0.84
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.29	1054.914	100.00
RUNOFF	6.913	225.835	21.41
EVAPOTRANSPIRATION	22.310	728.861	69.09
DRAINAGE COLLECTED FROM LAYER 1	2.7882	91.090	8.63
PERC./LEAKAGE THROUGH LAYER 2	0.505773	16.524	1.57
AVG. HEAD ON TOP OF LAYER 2	0.2563		
PERC./LEAKAGE THROUGH LAYER 3	0.013517	0.442	0.04
CHANGE IN WATER STORAGE	0.266	8.686	0.82
SOIL WATER AT START OF YEAR	33.876	1106.714	
SOIL WATER AT END OF YEAR	34.141	1115.400	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.58	1.43	2.41	3.24	4.20	5.40
	4.57	2.89	3.59	1.50	1.19	2.63
STD. DEVIATIONS	1.00	0.74	1.00	2.42	2.52	3.03
	1.67	1.43	1.37	0.49	0.57	0.93
RUNOFF						
TOTALS	1.300	0.471	1.292	0.741	0.365	0.756
	0.611	0.374	0.618	0.016	0.006	0.426
STD. DEVIATIONS	1.384	0.545	0.684	0.459	0.429	1.293
	0.467	0.356	0.555	0.020	0.013	0.387
EVAPOTRANSPIRATION						
TOTALS	0.668	0.926	1.276	2.032	3.102	3.788
	3.784	2.192	2.320	1.309	0.886	0.703
STD. DEVIATIONS	0.110	0.170	0.375	1.093	1.258	0.918
	1.441	1.240	0.455	0.446	0.290	0.226
LATERAL DRAINAGE COLLECTED FROM LAYER 1						
TOTALS	0.0203	0.0000	0.0023	0.6411	0.8234	0.4553
	0.6124	0.2402	0.7872	0.2243	0.0859	0.3474
STD. DEVIATIONS	0.0277	0.0000	0.0051	0.4690	0.6176	0.3654
	0.6525	0.2299	0.7903	0.2039	0.0755	0.5655
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0180	0.0000	0.0002	0.0601	0.0937	0.0631
	0.0531	0.0438	0.0646	0.0454	0.0387	0.0497
STD. DEVIATIONS	0.0247	0.0000	0.0004	0.0364	0.0220	0.0182
	0.0316	0.0204	0.0350	0.0097	0.0160	0.0567

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0017	0.0016	0.0017	0.0007	0.0005	0.0009
	0.0013	0.0012	0.0011	0.0013	0.0012	0.0014
STD. DEVIATIONS	0.0002	0.0001	0.0001	0.0005	0.0005	0.0005
	0.0006	0.0004	0.0003	0.0003	0.0003	0.0006

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 2

AVERAGES	0.0188	0.0000	0.0024	0.6747	0.8151	0.4503
	0.5650	0.2621	0.7068	0.2350	0.0957	0.3548
STD. DEVIATIONS	0.0258	0.0000	0.0054	0.4485	0.5527	0.2694
	0.5213	0.2428	0.5681	0.1964	0.0868	0.5555

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.63 (5.924)	1131.4	100.00
RUNOFF	6.976 (3.8065)	227.91	20.143
EVAPOTRANSPIRATION	22.987 (2.3014)	750.98	66.375
LATERAL DRAINAGE COLLECTED FROM LAYER 1	4.23969 (1.62573)	138.511	12.24212
PERCOLATION/LEAKAGE THROUGH FROM LAYER 2	0.53046 (0.09139)	17.330	1.53170
AVERAGE HEAD ACROSS TOP OF LAYER 2	0.348 (0.108)		
PERCOLATION/LEAKAGE THROUGH FROM LAYER 3	0.01464 (0.00125)	0.478	0.04227
CHANGE IN WATER STORAGE	0.415 (1.6547)	13.55	1.197

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	4.09	133.620
RUNOFF	2.412	78.8098
DRAINAGE COLLECTED FROM LAYER 1	0.32535	10.62905
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.004297	0.14037
AVERAGE HEAD ACROSS LAYER 2	4.736	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000068	0.00223
SNOW WATER	3.26	106.5115
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3696	
MINIMUM VEG. SOIL WATER (VOL/VOL)	-0.0053	

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	0.6220	0.1037
2	7.6860	0.4270
3	25.8335	0.1196
SNOW WATER	0.000	

Appendix P

APPENDIX P

CONSTRUCTION QUALITY ASSURANCE PLAN

Construction/Operation Level Design Report

Corrective Action Management Unit Grand Calumet River Sediment Remediation Project

U.S. Steel - Gary Works
Gary, Indiana

Prepared for:

U.S. Steel Group
Pittsburgh, PA

Prepared by:

Montgomery Watson
Madison, WI
October 2000

Revised by:

Earth Tech
Oakbrook, IL
August 2001

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LIST OF ATTACHMENTS~~PPENDICES~~

Attachment~~ppendix~~

A	Construction Testing and Frequency Tables
B	Project Specifications
C	Typical CQA Observation Logs

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1.0 INTRODUCTION

This Construction Quality Assurance Plan (CQAP) has been prepared in conjunction with the Corrective Action Management Unit (CAMU) Design for the Grand Calumet River Sediment Remediation Project at the U.S. Steel - Gary Work Facility in Gary, Indiana. This CQAP addresses quality assurance for construction of ~~the CAMU dewatering system (including the vertical barrier wall),~~ site security (perimeter fence), CAMU excavation and berm construction, on-site road construction, installation of the CAMU liner (and associated protection), installation of the leak detection/leachate collection systems, and installation of the storm water management system.

In the context of this CQAP, quality assurance refers to the means and actions employed to provide conformity of the CAMU ~~dewatering system,~~ liner system, leak detection/leachate collection systems, and the storm water management system production and installation with contractual and regulatory requirements. Quality assurance will be provided by a party independent of production and installation. Quality control refers to those actions taken to provide for materials and workmanship that meet the requirements of the design plans and specifications. Quality control is provided by the manufacturers and installers of the various components of the CAMU ~~dewatering system,~~ liner system, leak detection/leachate collection systems, and the storm water management system.

The main emphasis of this CQAP is careful documentation of the construction quality control process, ~~from the selection of materials through installation of the dewatering system (including the vertical barrier wall),~~ site security (perimeter fence), CAMU excavation and berm construction, on-site road construction, installation of the CAMU liner (and associated protection), installation of the leak detection/leachate collection systems, and installation of the storm water management system. The scope of this CQAP applies to manufacturing, shipping, handling, installing, and design guidelines. Detailed specifications for construction of the aforementioned components of the CAMU are contained in Appendix M of the Construction/Operation Level Design Report (COLDR).

The CQAP consists of a project description, a discussion of the project organization and responsibility, construction quality assurance activities including sample testing procedures, construction inspection, and documentation.

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2.0 PROJECT DESCRIPTION

2.1 SITE DESCRIPTION

The U.S. Steel - Gary Works facility is located in Lake County, Indiana. The Gary Works facility covers almost 4,000 acres and is located at the northern end of the City of Gary, Indiana and is approximately 25 miles southeast of downtown Chicago, Illinois. The Gary Works facility extends approximately 7 miles along the southern shore of Lake Michigan and is roughly 1 mile wide.

The CAMU area to be used for disposal is approximately 36.2 acres and is located adjacent to the U.S. Steel – Gary Works Facility. The CAMU consists of two Units: Unit 1 is for the TSCA and RCRA regulated non-native dredge spoils and Unit 2 will hold the remaining non-TSCA and RCRA dredge spoils. Unit 1 is approximately 7.0 acres and Unit 2 is approximately 29.2 acres.

2.2 PROJECT OBJECTIVES AND SCOPE

The objectives of the CAMU design and construction, as stated in the Statement of Work, is to provide containment and passive dewatering of dredged sediments as part of the Grand Calumet River Sediment Remediation Project. Proper containment requires installation of ~~the dewatering system (including the vertical barrier wall),~~ a site fence, CAMU excavation and berm construction, on-site road construction, installation of the CAMU liner (and associated protection), installation of the leak detection/leachate collection systems, and installation of the storm water management system. The proposed CAMU liner system is a completely synthetic liner system consisting of a: geosynthetic clay liner (GCL), secondary 60-mil high density polyethylene (HDPE) geomembrane, leak detection system (geonet composite and collection pipe), primary 60-mil HDPE geomembrane, and leachate collection system (geotextile cushion, sidewall geonet composite, and collection pipe). Protection for the geosynthetic liner system consists of a combination of geosynthetics and native granular material over the entire CAMU site.

Construction sequencing is addressed in Section 4.0 of the COLDR. The CAMU construction activities associated with the Grand Calumet River Sediment Remediation Project are briefly summarized as follows:

2.2.1 Vertical Barrier Wall (Section Deleted)

~~Initial clearing and grubbing along barrier wall alignment.~~

~~Remove existing dredge spoils in the area of the working bench.~~

~~Construct barrier wall working bench.~~

~~Excavate existing dredge spoils from outside the barrier wall alignment and place them inside the barrier wall alignment.~~

- ~~Construct vertical barrier wall.~~

2.2.2 Dewatering System (Section Deleted)

~~Install perimeter and interior extraction wells (EW02 through EW09).~~

~~Install temporary stand pipes (SP01 through SP03).~~

~~Abandon groundwater monitoring wells MW01, PO1, MW02, and MW03.~~

~~Install replacement monitoring wells MW01R, PO1R, and MW02R and new wells MW09 and P09.~~

~~Install dewatering system forcemain laterals and header.~~

~~Install electrical and control wires in forcemain trenches.~~

~~Install pipe connection manholes DMH01 through DMH10 and MH03).~~

~~Install groundwater collection manhole (MHGW).~~

~~Install control panels at each well and the main control panel at MHGW.~~

~~Install groundwater discharge pipe to Outfall 032 and pipe connection manhole (MH03).~~

2.2.3 Site Security

- Install permanent security fencing, gates, and warning signs around the entire site prior to any CAMU construction activities and in accordance with Section 6.

2.2.4 CAMU Excavation

- Final clearing and grubbing of site.
- Remove existing dredge spoils at berm locations and temporarily stockpile away from berms. Grade berm subbase for drainage.
- Install GCL under perimeter and interior berms.
- Install geonet composite over GCL under perimeter berms.
- Simultaneously excavate CAMU base grades and construct berms.
- Prepare base grade surface for GCL installation.

2.2.5 Berm Construction

- Begin construction of berms using temporarily stockpiled existing dredge spoils. Use existing dredge spoils to construct entire interior berm and the inside portion of the perimeter berms.
- Complete perimeter berm construction with existing dredge spoils and native sand material.
- ~~Extend dewatering wells during berm construction and continue well operation.~~
- Install storm water drainage pipes and ~~manholes~~ catch basins in perimeter berms as berms are being constructed.
- Reinforce inboard and outboard slopes of perimeter berms where necessary.

- Construct access roads into excavation as berms are being constructed.

2.2.6 Road Construction

- Construct perimeter access roads.
- Following liner installation, construct top of berm roads and finish off access roads into the excavation.

2.2.7 Liner System

- Excavate leak detection trenches and sumps.
- Install GCL over prepared base grades and extend up sideslopes.
- Install secondary geomembrane over GCL.
- Install geonet composite over secondary geomembrane.
- Install primary geomembrane over geonet composite.
- Install geotextile cushion on base and sidewall geonet composite on sideslopes over the primary geomembrane.

2.2.8 Leak Detection/Leachate Collection System

- Install leak detection collection pipes in trenches between the primary and secondary geomembrane.
- Construct leak detection system sumps (DS1-1, DS1-2, DS2-1, and DS2-2).
- Install leak detection system cleanouts ~~(DC01-1 through DC01-4 and DCO2-1 through DCO2-11)~~ and sump risers.
- Install pipe connection manholes (CM1-1, CM1-2, CM2-1, ~~and~~ CM2-2, and CM2-3).
- Install leachate collection pipes in trenches above the primary geomembrane.
- Construct leachate collection system sumps. ~~(LS1-1, LS1-2, LS2-1, and LS2-2).~~
- Install leachate collection system cleanouts ~~(LC01-1 through LC01-4 and LC02-1 through LC02-11)~~ and sump risers.
- Install granular drainage blanket layer over base of CAMU.
- Install leak detection and leachate collection system forcemain.
- Install electrical and control wires in forcemain trenches.
- Install leachate collection manholes ~~(MH01 and MH02).~~
- Install control panel at each pike connection manhole and the main control panel located near MH01 and MH02.
- Install leachate discharge line to PSWTP.

2.2.9 Liner Protection

- Install geotextile cushion and the granular drainage blanket on the base of Units 1 and 2.
- Sidewall geosynthetic protection will be designed by the CAMU operating contractor.

2.2.10 Storm Water Management System

- Install storm water drainage pipes and manholes during berm construction.
- Construct ~~infiltration basins~~ detention ponds and emergency overflow weir ~~structures and discharge piping~~ or temporary discharge culvert during berm construction.

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3.0 RESPONSIBILITY, AUTHORITY, AND QUALIFICATIONS

The responsibilities, authority, and qualifications identified in this CQAP are necessary to perform the CAMU construction activities.

3.1 CAMU OWNERS

3.1.1 Definition

The CAMU Owner is responsible for CAMU activities. For this project, U.S. Steel is the CAMU Owner.

3.1.2 Responsibility and Authority

The CAMU Owner is responsible for all the construction contracts. The CAMU Owner is responsible for coordinating communications with the regulatory agencies, Engineer, Earthwork Contractor, and Geosynthetic Contractor for the project. The CAMU Owner is also responsible for initiating the preconstruction, prefinal, and final inspections as presented in Section 13 - Inspection Activities of this CQAP. The CAMU Owner will serve as a liaison between all parties involved in construction to maintain communications.

The CAMU Owner has the ultimate responsibility for installation of the ~~dewatering system (including the vertical barrier wall),~~ site fence, CAMU excavation and berm construction, on-site road construction, installation of the CAMU liner (and associated protection), installation of the leak detection/leachate collection systems, and installation of the storm water management system, in accordance with the design plans and specifications.

3.1.3 Qualifications

The selection of the CAMU Owner's representative is the responsibility of the CAMU Owner. The CAMU Owner's representative should be familiar with the ~~construction of dewatering systems (including the vertical barrier wall),~~ excavation and berm construction, road construction, liner installation, leak detection/leachate collection systems, storm water management systems, and regulatory requirements of the U.S. Environmental Protection Agency (USEPA) and the Indiana Department of Environmental Management (IDEM).

3.1.4 Submittals

The CAMU Owner is responsible for submitting required information to USEPA. Submittals include:

- Design drawings and specifications
- Progress reports
- Record Drawings
- Construction Completion Report

3.2 ENGINEER

3.2.1 Definition

The Engineer is the individual/firm responsible for design of the ~~dewatering system (including the vertical barrier wall).~~ site fence, CAMU excavation and berm, on-site roads, CAMU liner, leak detection/leachate collection systems, storm water management system, including reports, drawings, plans, and specifications. The Engineer is also the individual/firm responsible for interpretation of the design plans and specifications during construction.

3.2.2 Responsibility and Authority

The Engineer is responsible for performing the engineering design and preparing the associated drawings and specifications for the CAMU construction activities. The Engineer is responsible for interpretation of the design, drawings, and specifications during construction. The Engineer is responsible for approving all design and specification changes and making design clarifications necessary during CAMU construction activities.

The Engineer must attend the preconstruction meeting, prefinal inspection, and final inspection as discussed in Section 13 - Inspection Activities, of this CQAP. The Engineer reports directly to the CAMU Owner.

3.2.3 Qualifications

The Engineer must be a qualified professional engineer, licensed in the State of Indiana. The Engineer must be familiar with the following:

- Geotechnical design methods and procedures
- Geosynthetic design methods and procedures
- ~~Installation of dewatering systems~~
- Installation of liners systems
- Installation of leak detection/leachate collection systems
- Applicable regulatory requirements

3.2.4 Submittals

The Engineer is responsible for submittal of the following documentation to the CAMU Owner:

- Design drawings and specifications
- Documentation of approved design changes
- Progress reports

3.3 CONSTRUCTION QUALITY ASSURANCE ENGINEER

3.3.1 Definition

The Construction Quality Assurance (CQA) Engineer is the engineer personally in charge of the construction quality assurance work. The CQA Engineer shall not be an employee of the CAMU Owner or Contractor of the site. The CQA Engineer may be an employee of ~~the CAMU Owner~~

~~or~~ the Engineer. In some cases, the duties of the CQA Engineer may be shared by two individuals; a CQA Engineer located in the office, and a Site Technician located at the site. The Site Technician reports directly to the CQA Engineer.

3.3.2 Responsibility and Authority

The Site Technician is responsible for observing and documenting activities related to the installation of the ~~dewatering system (including the vertical barrier wall),~~ site fence, CAMU excavation and berm, on-site roads, CAMU liner (and associated protection), leak detection/leachate collection systems, and storm water management system. The CQA Engineer is ultimately responsible for seeing that the field observation and documentation is complete and for preparing a Construction Completion Report as outlined in Section 14 - Documentation, of this CQAP.

The Site Technician will observe and document the activities of the Contractors in sufficient detail and with sufficient continuity to provide a high level of confidence that the work product complies with the design plans and specifications. The CQA Engineer and/or the Site Technician will also verify that installation requirements are met and that all submittals from the Contractors are provided. In addition, the CQA Engineer and/or the Site Technician will perform and repeat tests, as necessary, to provide a high degree of certainty that the physical/mechanical characteristics of ~~the dewatering system (including the vertical barrier wall),~~ the site fence, CAMU excavation and berms, on-site roads, CAMU liner, leak detection/leachate collection systems, and storm water management system meet or exceed specifications.

The Site Technician must maintain daily reports of earthwork and geosynthetic quality control activities. These reports will include, at a minimum, visual observations and test results. In addition, these reports will summarize significant events and problems encountered and resolved. These daily reports will be submitted to the CQA Engineer.

Any differences between the CQA Engineer's interpretation of the design plans and specifications from the Contractors' interpretation must be resolved by the Engineer. If such assessment indicates any actual or suspected work deficiencies, the CQA Engineer must inform the Contractors' of these deficiencies.

3.3.3 Qualifications

The CQA Engineer and the Site Technician must be experienced in the preparation of quality assurance documentation, including quality assurance forms, reports, and as-built drawings. The CQA Engineer and Site Technician must be experienced in the observation of ~~installation of dewatering systems (including the vertical barrier wall),~~ excavation and berm construction, road construction, liner installation, leak detection/leachate collection systems, storm water management systems. The Site Technician must be NICET approved for installing high density polyethylene (HDPE) geomembrane, geonet, and geotextile. The CQA Engineer shall be a qualified professional engineer with active licensing in the State of Indiana.

3.3.4 Submittals

The Site Technician will be responsible for submitting daily field reports to the CQA Engineer throughout the construction period. The CQA Engineer will be responsible for submitting the Construction Completion Report and record drawings to the CAMU Owner.

3.4 BARRIER WALL CONTRACTOR (Section Deleted)

~~3.4.1 Definition~~

~~The Barrier Wall Contractor is the individual/firm responsible for construction components of the vertical barrier wall.~~

~~3.4.2 Responsibility and Authority~~

~~The Barrier Wall Contractor is responsible for installing the vertical barrier wall system in conformance with the design plans and specifications. The Barrier Wall Contractor may also be responsible for locating and transporting the required materials, and other work, as outlined in the specifications.~~

~~The Barrier Wall Contractor will be under contract with the CAMU Owner. The Barrier Wall Contractor may be a subcontractor of the Earthwork Contractor, or may be the same company as the Earthwork Contractor.~~

~~3.4.3 Qualifications~~

~~The Barrier Wall Contractor must be approved by the CAMU Owner. The Barrier Wall Contractor must be able to provide qualified personnel to meet the demands of the project. The Barrier Wall Contractor, unless otherwise approved by the CAMU Owner, must be qualified based on previously demonstrated experience and management ability. The Barrier Wall Contractor must have experience with installation of vertical barrier wall systems.~~

~~3.4.4 Submittals~~

~~Well in advance of beginning barrier wall construction activities, the Barrier Wall Contractor must submit to the CAMU Owner and CQA Engineer, the following:~~

- ~~A list of specific equipment to be used on the project~~
- ~~Company background and information~~
- ~~A demonstration of bonding capabilities~~
- ~~A list of at least three comparable projects~~

3.5 WELL DRILLING CONTRACTOR

3.5.1 Definition

The Well Drilling Contractor is the individual/firm responsible for drilling and installation of ~~dewatering system wells,~~ monitoring wells~~,~~ and temporary stand pipes. The Well Drilling Contractor is also responsible for monitoring well abandonment.

3.5.2 Responsibility and Authority

The Well Drilling Contractor is responsible for drilling and installing the ~~dewatering system wells,~~ monitoring wells, and temporary stand pipes, and abandoning monitoring wells, in conformance with the design plans and specifications. The Well Drilling Contractor may also be responsible for locating and transporting the required materials, and other work, as outlined in the specifications.

The Well Drilling Contractor will be under contract with the CAMU Owner. Well Drilling Contractor may be a subcontractor of the Earthwork Contractor.

3.5.3 Qualifications

The Well Drilling Contractor must be approved by the CAMU Owner. The Well Drilling Contractor must be able to provide qualified personnel to meet the demands of the project. The Well Drilling Contractor, unless otherwise approved by the CAMU Owner, must be qualified based on previously demonstrated experience and management ability. The Well Drilling Contractor must have experience with installation of ~~dewatering wells and~~ monitoring wells.

3.5.4 Submittals

Well in advance of beginning well installation activities, the Well Drilling Contractor must submit to the CAMU Owner and CQA Engineer, the following:

- A list of specific equipment to be used on the project.
- Company background and information.
- A demonstration of bonding capabilities.
- A list of at least three comparable projects.

3.6 EARTHWORK CONTRACTOR

3.6.1 Definition

The Earthwork Contractor is the individual/firm responsible for earthwork, including site preparation and grading and construction components of the CAMU excavation and berm construction, and for the leak detection, leachate collection (including granular drainage, blanket) and storm water management systems, including installation of the horizontal piping systems, sumps, manholes, side-slope risers, and infiltration basins.

3.6.2 Responsibility and Authority

The Earthwork Contractor is responsible for the CAMU excavation and berm construction (including geosynthetic reinforcement), and installation of the CAMU, leak detection/leachate collection systems (including granular drainage blanket), and storm water management systems in conformance with the design plans and specifications. The Earthwork Contractor may also be responsible for locating and transporting the required materials, and other work, as outlined in the specifications.

3.6.3 Qualifications

The Earthwork Contractor must be approved by the CAMU Owner. The Earthwork Contractor must be able to provide qualified personnel to meet the demands of the project. The Earthwork Contractor, unless otherwise approved by the CAMU Owner, must be qualified based on previously demonstrated experience and management ability. The Earthwork Contractor must have experience with excavation and berm construction (including geogrid reinforcement), road construction, leak detection/leachate collection systems, and storm water management systems.

3.6.4 Submittals

Well in advance of beginning earthwork activities, the Earthwork Contractor must submit to the CAMU Owner and CQA Engineer, the following:

- A list of specific equipment to be used on the project.
- Company background and information.
- A demonstration of bonding capabilities.
- A list of at least three comparable projects.

3.7 GEOSYNTHETIC CONTRACTOR

3.7.1 Definition

The Geosynthetic Contractor is the individual/firm responsible for supplying and installing the geosynthetic clay liner (GCL), geomembrane, geonet composite, and geotextile components of the CAMU liner.

3.7.2 Responsibility and Authority

The Geosynthetic Contractor is responsible for installing the GCL, geomembrane, geonet composite, and geotextile in conformance with the design plans and specifications. The Geosynthetic Contractor is also responsible for supplying and transporting the required materials as outlined in the specifications.

The Geosynthetic Contractor will be under contract with the CAMU Owner or may be a subcontractor of the Earthwork Contractor.

3.7.3 Qualifications

The Geosynthetic Contractor must be approved by the CAMU Owner. The Geosynthetic Contractor must be able to provide qualified personnel to meet the demands of the project. The Geosynthetic Contractor, unless otherwise approved by the CAMU Owner, must be qualified based on previously demonstrated experience and management ability. The Geosynthetic Contractor must have experience with installation of GCL, HDPE geomembrane, geonet composite, and other geotextile components of the liner system.

3.7.4 Submittals

Well in advance of beginning geosynthetic installation activities, the Geosynthetic Contractor must submit to the CAMU Owner and CQA Engineer, the following:

- A list of specific equipment to be used on the project.
- Company background and information.
- A demonstration of bonding capabilities.
- A list of at least three comparable projects.
- A detailed panel layout for the geomembrane.

3.8 GEOTECHNICAL LABORATORY

3.8.1 Definition

The Geotechnical Laboratory is a firm, independent of the CAMU Owner and the Contractors, responsible for conducting tests on soil samples submitted by the CQA Engineer.

3.8.2 Responsibility and Authority

The Geotechnical Laboratory is responsible for conducting appropriate laboratory tests as directed by the CQA Engineer. The test procedures must be done in accordance with the test methods outlined in the specifications and this CQAP. The Geotechnical Laboratory is responsible for providing report ready test results.

3.8.3 Qualifications

The Geotechnical Laboratory must have an acceptable program for maintaining and calibrating testing equipment. The Geotechnical Laboratory must demonstrate that laboratory testing is performed by personnel with experience and/or training in soil testing fundamentals. The laboratory personnel must be familiar with ASTM and AASHTO test standards. The Geotechnical Laboratory must be capable of providing test results in a timely manner to meet project needs.

3.8.4 Submittals

The Geotechnical Laboratory will submit test results to the CQA Engineer within the agreed time frames. Written test results will be in an easily readable format and include references to the standard test method used.

3.9 GEOSYNTHETIC LABORATORY

3.9.1 Definition

The Geosynthetic Laboratory is a firm, independent of the CAMU Owner and the Contractors, responsible for conducting tests on geosynthetic samples submitted by the CQA Engineer.

3.9.2 Responsibility and Authority

The Geosynthetic Laboratory is responsible for conducting appropriate laboratory tests as directed by the CQA Engineer. The test procedures must be done in accordance with the test methods outlined in the specifications and this CQAP. The Geosynthetic Laboratory is responsible for providing report ready test results.

3.9.3 Qualifications

The Geosynthetic Laboratory must have an acceptable program for maintaining and calibrating testing equipment. The Geosynthetic Laboratory must be a Geosynthetic Accreditation Institute - Laboratory Accreditation Program (GAI-LAP) accredited laboratory. The Geosynthetic Laboratory must demonstrate that laboratory testing is performed by personnel with experience and/or training in geosynthetic testing fundamentals. The laboratory personnel must be familiar with ASTM and GRI test standards. The Geosynthetic Laboratory must be capable of providing test results in a timely manner to meet project needs.

3.9.4 Submittals

The Geosynthetic Laboratory will submit test results to the CQA Engineer within the agreed time frames. Written test results will be in an easily readable format and include references to the standard test method used.

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4.0 VERTICAL BARRIER WALL (Section Deleted)

~~4.1 OBSERVATION AND INSPECTION~~

~~Observation and inspection of vertical barrier wall construction will be performed by the CQA Engineer and will include the following:~~

- ~~Visual observation and photodocumentation of initial clearing and grubbing, existing dredge spoil removal, working bench construction, and vertical barrier wall construction.~~

- ~~Visual observation of the lateral and vertical limits of the vertical barrier wall construction.~~

- ~~Documentation of trench grades.~~

- ~~Visual classification, documentation, and sample collection for laboratory testing of the clay key in material.~~

- ~~Obtaining samples for laboratory testing from the slurry and soil bentonite backfill material.~~

~~4.2 CONSTRUCTION TESTING~~

~~Both in field and laboratory testing will be performed to document materials used and method of placement for the vertical barrier wall.~~

~~4.2.1 Trenching~~

~~Measurements must be collected to verify trench depth prior to backfilling with soil bentonite backfill material. Trench length will also be confirmed by survey.~~

~~In field testing will be performed at the frequency shown in Table 1 of this CQAP. Testing will include:~~

- ~~Depth measurements will be collected every 10 linear feet.~~

- ~~Survey length of trench, daily.~~

~~4.2.2 Key In Material~~

~~The native clay key in material will be visually classified in the field and samples will be submitted for testing to the geotechnical laboratory.~~

~~In field and laboratory testing will be performed at the frequency shown in Table 1 of this CQAP. Testing will include:~~

- ~~Natural Moisture (ASTM D 2216).~~

~~Atterberg Limits (ASTM D4318).~~

~~Grain Size Analysis – (ASTM D422; sieve and hydrometer)~~

~~4.2.3 Slurry~~

~~The slurry used in the vertical barrier wall construction must be able to form a low permeability filter cake on the wall of the trench. The density of the slurry must be great enough to provide sufficient pressure against the trench walls to keep the trench open, but not so dense that it can not be pumped from the slurry pond.~~

~~In field and laboratory testing will be performed at the frequency shown in Table 1 of this CQAP. Testing will include:~~

~~Marsh Funnel Test (40 Marsh seconds or greater)~~

~~Density~~

~~Filtrate Loss (<30 cc after 30 minutes at 100 psi)~~

~~pH (7-10)~~

~~Measure slurry level – (no lower than 2 ft below working bench)~~

~~Sand content of slurry at holding pond and near bottom of trench.~~

~~**4.2.4 Soil-Bentonite Backfill**~~

~~The soil-bentonite backfill will consist of native sand mixed with fines to provide a low hydraulic conductivity with adequate slump and density (i.e. the backfill must be dense enough to displace the slurry).~~

~~In field and laboratory testing will be performed at the frequency shown in Table 1 of this CQAP. Testing will include:~~

~~Slump Test (ASTM C143; 3-7 inches)~~

~~Permeability Test (ASTM D5084; <1x10^{-7} cm/s)~~

~~Density (unit weight) 15 lb/ft^3 greater than slurry density near trench bottom~~

~~Grain Size Analysis (ASTM D422; P200 > 30%)~~

~~Excavation Toe Location (Station) and depth.~~

~~Trench Backfill Location (Station) and depth.~~

~~4.3 FAILING TESTS OR MATERIALS~~

~~If failing tests occur adjustments will be made to the slurry and/or soil-bentonite backfill to obtain the required properties.~~

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5.0 DEWATERING SYSTEM (Section Deleted)

~~The dewatering system consists of the following components:~~

- ~~Dewatering wells, including:~~
  - ~~Pumps~~
  - ~~Pitless adapter~~
  - ~~Pressure transducer~~

- ~~Dewatering conveyance system, including:~~
  - ~~Dewatering system forcemain~~
  - ~~Pipe connection manholes~~
  - ~~Valves and flow meters~~
  - ~~Groundwater collection manhole, pumps, and discharge pipe~~

- ~~Electrical and control systems at each well and at the groundwater collection manhole.~~

~~5.1 OBSERVATION AND INSPECTION~~

~~The CQA Engineer will be present on site on a full-time basis during construction to document that construction of the dewatering system is performed in accordance with the design plans and specifications. The CQA Engineer will be responsible for the following items:~~

- ~~Observe installation and development of the dewatering wells.~~

- ~~Observe horizontal piping installations (including valves) and obtain dewatering system forcemain pipe inverts and location information.~~

- ~~Observe pressure testing of piping systems.~~

- ~~Observe and document excavations, bedding, and backfill of pipe trenches and manhole excavations.~~

- ~~Observe installation of the dewatering pumps.~~

- ~~Observe installation of pipe connection manholes and the groundwater collection manhole.~~

- ~~Observe installation of valves and flow meters.~~

- ~~Observe installation of the electrical and control systems.~~

- ~~Survey pertinent system inverts and elevations.~~

- ~~Maintain daily field notes and testing records regarding project construction.~~

- ~~Observe working condition of all dewatering system components.~~

- ~~Provide photographic documentation of major construction activities.~~

~~5.2 CONSTRUCTION TESTING~~

~~In field testing will be performed to document that installation and materials used are in conformance with the design drawings and specifications. The Earthwork Contractor is responsible for selecting materials and components that meet project requirements. The Earthwork Contractor will submit manufacturers' information regarding selected materials for approval prior to installation. Specific testing and sampling activities for the dewatering system are discussed below.~~

~~5.2.1 Groundwater Dewatering Wells~~

~~The well screen shall consist of an 8 in. diameter 0.20 in. slot, "High Q", stainless steel screen. The well materials of construction include 8 in. (stainless steel) pipe, 3 in. pitless adapter, 3 in. BCS outlet pipe, and associated fittings. The pipe assemblies will be air pressure tested by the Earthwork Contractor after installation to document integrity of the pipe and pipe connections. Air pressure testing will be performed in accordance with the specifications and the construction will be documented by the CQA Engineer. Refer to Drawings D5 and D10 of the COLDR for well locations and well details, respectively.~~

~~5.2.2 Pipe Bedding Material and Trench Backfill~~

~~Pipe bedding and backfill materials will conform with the specifications and placement will be documented by the CQA Engineer.~~

~~In field and laboratory testing will be performed at the frequency shown in Table 1 of this CQAP. Testing will include:~~

- ~~Field Moisture (ASTM D2922)~~
- ~~Field Density (ASTM D3017)~~
- ~~Modified Proctor Moisture - Density Relationship (ASTM D1557)~~
- ~~Grain Size Analysis (ASTM D422; sieve and hydrometer).~~

~~5.2.3 Dewatering Piping System~~

~~The dewatering system forcemain lateral from the pump outlet pipe to the forcemain header consists of 2 in. diameter standard dimension ratio (SDR) 11 HDPE pipe and associated fittings. The dewatering forcemain header consists of 6 in. diameter SDR 11 HDPE pipe and associated fittings. The buried pipe systems will be air pressure tested by the Earthwork Contractor after installation to document integrity of the pipe and pipe connections. Air pressure testing will be performed in accordance with the specifications and documented by the CQA Engineer. Construction will be documented by the CQA Engineer. Refer to Drawings D5 and D10 of the COLDR for the forcemain locations and details, respectively.~~

~~5.2.4 Groundwater Collection Manhole~~

~~The groundwater collection manhole (MHGW) is constructed of pre-cast concrete. The Groundwater Collection Manhole will be installed by excavating the native material to the design elevation. The backfill around the manhole will be compacted to 90% of the modified Proctor maximum dry density and will be tested for compactive effort at the frequencies detailed on Table 1. Construction will be documented by the CQA Engineer. Refer to Drawings D5 and D20 of the COLDR for manhole location and details, respectively.~~

~~5.2.5 Pumps~~

~~The dewatering well pumps and manhole pumps will be installed based on manufacturers' and suppliers' requirements. The pumps and controls will be observed to be in working order upon completion of installation. Electrical and control system components requirements are described in the specifications.~~

~~5.2.6 Electrical and Controls~~

~~The electrical service to the CAMU dewatering system is 480 volt, 3 phase, 4 wire power and extends from the existing service near the former Select Beverage facility to the CAMU dewatering system. Electrical service includes a service entrance, utility meter, main disconnect, transformers, electrical and control panels, and related equipment. Electrical and control wires run to the groundwater collection manhole and each dewatering well. Construction will be documented by the CQA Engineer.~~

~~The dewatering system controls will be installed based on manufacturers' and suppliers' requirements. The controls will be observed to be in working order upon completion of installation. Electrical and control system components' requirements are described in the specifications.~~

~~5.3 FAILING TESTS OR MATERIALS~~

~~If failing field tests occur for any of the pressure-tested components of the dewatering system, the leak will be identified, repaired/replaced, and retested to achieve passing tests. If any field density and moisture test results are outside of acceptable ranges, the areas will be reworked and retested to achieve passing tests. Unacceptable subbase material under manholes and underground piping will be removed and replaced with acceptable material. Any malfunctioning electrical or mechanical equipment will be replaced.~~

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6.0 SITE SECURITY

A permanent security fence will be placed around the perimeter of the CAMU site, ~~as shown on Drawing D6 of the COLDR,~~ prior to start of the CAMU construction activities. ~~Details on the permanent security fence are shown on Drawing D18 of the COLDR.~~

This section addresses the construction quality assurance procedures for installation of the permanent security fence.

6.1 MATERIAL QUALITY CONFIRMATION

The selection of the material used for the permanent security fence must be approved by the Engineer prior to installation and in accordance with the following:~~.~~

- Drawing D6 of the COLDR.
- Details shown on Drawing D18 of the COLDR.
- Specification Section 02831 - Chain Link Fences and Gates (Attachment B).

6.2 OBSERVATION AND INSPECTION

Construction observation, photodocumentation, and inspection will occur during fence installation. Defects observed in the installed fence will be replaced. Inspection will also include surveying the permanent security fence location for permanent record which will be included in the Construction Completion Report. Construction observation and inspection will be performed by the CQA Engineer.

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7.0 CAMU EXCAVATION

CAMU construction involves excavating existing dredge spoils and native soils at the site and preparing the base grade surface for liner system placement.

7.1 OBSERVATION AND INSPECTION

Observation and inspection of CAMU excavation will be performed by the CQA Engineer and will include the following:

- Observe and document monitoring well abandonments and well installation (replacement wells and new wells).
- Observe clearing and grubbing activities.
- Visual observation and photodocumentation of the CAMU excavation.
- Visual observation of the lateral and vertical limits of the CAMU excavation.
- Observe subbase soil so that unsuitable soil is not present.
- Observe smooth drum rolling of the base grade layer ~~following excavation~~ prior to liner system construction activities.
- Perform field density tests on ~~base grade~~ compacted backfill material.
- Obtain samples for ~~geotechnical~~ laboratory testing from the base and sidewalls of the excavation.

7.2 CONSTRUCTION TESTING

Earthwork Contractor is to excavate the CAMU to the grades and geometry as shown on Drawing D7 and Specification Section 02220 - Excavating, Backfilling and Compaction (Attachment B).

The CQA Engineer shall observe all excavation activities associated with the CAMU. Excavation activities will include the removal of existing dredge spoils and native soils to obtain grades and geometry of the CAMU. The CQA Engineer shall verify and document:

- Vertical and horizontal limits of excavation.
- Resulting excavated surface (subbase) is free of organics and does not contain any soft areas.
- Vertical and horizontal limits of any overexcavation.

After completion of subbase documentation, Earthwork Contractor shall backfill areas overexcavated with compacted backfill. The CQA Engineer will perform the following tests on the compacted backfill in accordance with Specification Section 02220 (Attachment B) and Table 1A (Attachment A).

- Grain size distribution (ASTM D422).
- Modified Proctor (ASTM D1552).
- In-Place nuclear density/moisture testing (ASTM D2122 and D3017).
- In-Place density of all backfill shall be 90 percent maximum dry density as determined by the Modified Proctor.

CQA Engineer shall approve grades by survey on a minimum 100-foot grid and at major grade breaks for tolerances defined in Specification Section 02220 3.6.

~~The base grade surface will be visually observed for adequate compaction of the material, as detailed in the specifications. Base grades will be constructed to the lines and grades shown on Drawing D7 of the COLDR. Base grades will be surveyed on a 100 foot grid. Both in field and laboratory testing will be performed to document materials used and base grade preparation of the CAMU excavation.~~

~~In_ field and laboratory testing will be performed at the frequency shown in Table 1 of this CQAP. Testing will include:~~

~~-Survey base grades~~

7.3 FAILING TESTS OR MATERIALS

Unacceptable subbase material will be removed and replaced with acceptable material.

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8.0 BERM CONSTRUCTION

CAMU perimeter and interior berms will be constructed using existing dredge spoils and native soils at the site such that cut and fill is nearly balanced.

8.1 OBSERVATION AND INSPECTION

Observation and inspection of CAMU berm construction will be performed by the CQA Engineer and will include the following:

- Visual observation and photodocumentation of the CAMU berm construction.
- Visual observation of the lateral and vertical limits of the CAMU berms.
- Documentation of berm grades.
~~Documentation of GCL installation procedures.~~
- Documentation of slope reinforcement installation procedures.
- Collection of samples for geotechnical laboratory analysis.

8.2 CONSTRUCTION TESTING

Both in-field and laboratory testing will be performed to document materials used and method of berm construction including stabilization methods.

In field and laboratory testing will be performed at the frequency shown in Table 1A (Attachment A)~~1~~ of this CQAP. Testing will include:

- Field Moisture (ASTM D2922).
- Field Density (ASTM D3017).
- Modified Proctor Moisture - Density Relationship (ASTM D1557).
- Survey on a ~~100-foot grid per ft~~100 lineal feet.
- ~~GCL bentonite mass/area~~Unconfined Compressive Strength (ASTM D2166)(1).

(1) For dredge spoil/lime kiln amended soil only. Sample shall be an in-place sample collected immediately upon lift compaction. The sample shall be allowed to cure under the same conditions as the remaining berm soils. Sample shall be tested on the 8th day of curing.

8.2.1 Dredge Spoil/Lime Kiln Amended Soils and Geogrid Reinforcement

A portion of the perimeter berm will be constructed from amended soil materials which will consist of on-site dredge spoils, locally available lime kiln dust, and a geogrid reinforcement. The CQA Engineer shall monitor all on-site mixing, placement, and compaction of the amended soil. The amended soil shall be mixed in the following manner:

- All mixing of the amended soil shall occur on-site in Owner designated areas.
- All soils shall be mixed and moisture conditioned prior to placement within the berm limits.
- The soil shall be monitored for proper proportioning. The specified mixture is:

a. ____ yards of on-site dredge spoil, in-situ.

b. ____ yards of lime kiln dust, hydrated to ______.

c. Moisture content shall be approximately ____.

CQA Engineer shall observe and document geogrid reinforcement installation in accordance with Technical Specification 02776 - Geogrid Scope Reinforcement (Attachment B).

8.2.2~~1~~ Topsoil Layer

A topsoil layer that is capable of supporting vegetation is required as the final layer on the outboard slopes of the berms. No field testing will be required of the topsoil layer.

8.2.3~~2~~ Storm Water and Erosion Control Structures

The underground portion of the storm water management system will be constructed prior to and during berm construction activities. Refer to Section 12 of this CQAP for more details on storm water management.

8.3 FAILING TESTS OR MATERIALS

If any field density and moisture test results are outside of acceptable ranges, the areas will be reworked and retested to achieve passing tests. Unacceptable subbase material will be removed and replaced with acceptable material.

8.4 REFERENCE DOCUMENTS

- Technical Specification 02220 - Excavating, Backfilling, and Compacting (Attachment B).
- Technical Specification 02776 - Geogrid Slope Reinforcement (Attachment B).
- Table 1A (Attachment A).
- Drawing Nos. 2, 7, and 21.

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9.0 ROAD CONSTRUCTION

Operation of the CAMU requires vehicular access around the perimeter of the site as well as on top of the perimeter and interior berms. Roads will also be constructed to provide access to the bottom of Units 1 and 2.

9.1 OBSERVATION AND INSPECTION

Observation and inspection of CAMU road construction will be performed by the CQA Engineer and will include the following:

- Visual observation and photodocumentation of the CAMU road construction.
- Documentation of road grades.
- Obtaining samples for geotechnical laboratory testing of the base course and surface course materials at frequencies shown in Table 1B of this CQAP.

9.2 CONSTRUCTION TESTING

Both in-field and laboratory testing will be performed to document materials used and method of road construction.

9.2.1 Base Course

The base course used for the access roads will be tested both in the field and in the laboratory. In-field and laboratory testing will be performed at the frequency shown in Table 1B of this CQAP. Testing will include the following:

- Field Moisture (ASTM D2922).
- Field Density (ASTM D3017).
- Grain Size Distribution (ASTM D422; sieve).
- Modified Proctor Moisture-Density Relationship (ASTM D1557).
- Survey on a 100-LF of roadway.~~foot grid~~

9.2.2 Surface Course

The surface course will be tested in the field for thickness and compaction. Infield testing will be performed at the frequency shown in Table 1B of this CQAP. Testing will include the following:

- Field Moisture (ASTM D2922).
- Field, Density (ASTM D3017).
- Modified Proctor Moisture-Density Relation (ASTM D1557).
- Grain Size Distribution (ASTM D422; sieve).
- Survey on a 100-LF of roadway.~~foot grid~~

9.2.3 Reinforcing Geotextile

CQA Engineer shall observe and document reinforcing geotextile installation in accordance with Technical Specification 02777 - Reinforcing Geotextile (Attachment B).

9.3 FAILING TESTS OR MATERIALS

If any field or laboratory tests are outside the acceptable range, the material will either be reworked until it is within acceptable range or will be removed and replaced with acceptable material.

9.4 REFERENCE DOCUMENTS

- Technical Specification 02220 - Excavating, Backfilling, and Compacting (Attachment B).
- Technical Specification 02777 - Reinforcing Geotextile (Attachment B).
- Tables 1A and 1B (Attachment A).
- Drawing Nos. 5-8, 16, 17, and 21.

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10A GEOSYNTHETIC CLAY LINER (GCL)~~.0 LINER SYSTEM~~

10A.1~~.1~~ ~~OBSERVATION AND INSPECTION~~OBSERVATION AND INSPECTION

The CQA Engineer will be present on-site on a full-time basis during all components of GCL installation to document construction is performed in accordance with the design plans and specifications. The CQA Engineer will be responsible for the following:

- Observe and document installation of the GCL.
- Observe and document the installation of all subsequent layers overlying and underlying the GCL.
- Collect samples of GCL for conformance testing.
- Obtain and record survey information.
- Maintain daily field notes regarding GCL installation.
- Provide photographic documentation of major construction activities.

10A.2 QUALITY CONTROL DOCUMENTATION

Prior to the delivery to Site, the Contractor shall perform the following activities pertaining to the GCL:

- Submit samples of the GCL to the Owner. Materials properties shall be in conformance with Table 1F (Attachment A). Any deviation shall be documented and approved by the Engineer.
- Interface friction angle testing with on-site native sands and proposed textured HDPE geomembrane.
- Copy of warranty obtained from Manufacturer.
- Copy of quality control certificates indicating compliance with Table 1F (Attachment A).

The GCL shall be a prefabricated panel manufactured with the following characteristics:

- 1 lb/sf uniform layer of natural sodium bentonite which contains 90 percent sodium montmorillonite. Sodium bentonite is to be from excavated materials from west United States.
- The sodium bentonite layer shall be sandwiched between to non-woven, needle-punched, polyester, or polypropylene geotextile.
- The GCL shall be internally reinforced.
- The GCL shall be self-healing. Adhesives or threads used in the production of the geotextiles or GCL shall not hamper the self-healing capabilities.

The Manufacturer shall identify each roll supplied with the following label information:

- Manufacturer's name.
- Product identification.
- Roll number.
- Roll weight.
- Roll dimensions.
- Date of manufacture.

- Lot number.

10A.3 DELIVERY AND STORAGE

The CQA Engineer shall visually observe the unloading and storage of the GCL and document the following:

- GCL rolls are properly numbered and material identification readily visible from the Manufacturer.
- Rolls damaged during unloading are identified and segregated from the main stockpile.
- Verify shipping manifest as to the total GCL rolls received on-site.
- Rolls are protected from direct sunlight, rain, standing water, and heat to prevent degradation of material. Storage and protection of the GCL is the responsibility of the Contractor.

10A.4 CONFORMANCE TESTING

At a minimum, the following conformance tests shall be conducted on the GCL as a unit at a minimum frequency of 100,000 sf received on-site:

- Bentonite Mass/Area (ASTM D5993).
- GCL Grab Tensile Strength (ASTM D4632).
- GCL Peel Strength (ASTM D4632).

All conformance test results shall be reviewed and accepted or rejected by the CQA Engineer prior to the deployment of the GCL. The CQA Engineer shall examine all results from laboratory conformance testing and shall report any nonconformance to the Owner. The CQA Engineer shall be responsible for checking that all test results meet or exceed the property values listed in Table 1F (Attachment A).

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic Laboratory incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic Laboratory with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic Laboratories. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic Laboratory's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Owner.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of Owner, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

10A.5 BASE GRADE PREPARATION

The base grade shall be prepared in accordance with Section 7 of this CQAP.

10A.6 DEPLOYMENT

The GCL shall be deployed by the Contractor in the follow means:

- GCL shall be placed such that all seams run parallel with the direction of the slope. No horizontal seams are allowed on slopes.
- GCL shall be dry when placed. Wet or hydrated GCL shall not be installed. GCL which becomes hydrated prior to and after geomembrane installation shall be removed and replaced.
- Equipment used in the deployment and handling of the GCL shall not damage the GCL from trafficking, leakage of hydrocarbons (gasoline or oils), or other means.
- Personnel working on the GCL shall not smoke, wear damaging shoes, or engage in activities which could damage the GCL.
- Methods for deployment shall not cause the GCL to be scratched or crimped nor damage supporting base grade soils.
- Methods used for GCL deployment shall minimize wrinkles (especially differential wrinkles between adjacent panels).
- Direct contact with GCL shall be minimized. Trafficked areas shall be protected by geotextiles, geomembranes, or other suitable materials.
- GCL shall be immediately covered and protected by the overlying layer of the liner system.
- Personnel working on areas greater than 3H:1V shall wear proper fall protection.

10A.7 WEATHER CONDITIONS

The CQA Engineer shall observe and document the following:

- GCL is not deployed during precipitation events, in presence of excessive moisture (i.e. fog, dew, or in areas of ponded water).
- Adequate temporary loading such as sand bags or tires shall be provided to prevent GCL uplift due to strong winds.

10A.8 SEAMING

GCL seams shall be constructed by the following requirements:

- Adjoining or longitudinal seams shall have a minimum 6-inch overlap and end seams shall be overlapped a minimum of 24 inches.
- GCLs without continuous adhesion of the bentonite tot he geotextile (needle punched) shall be overlapped as above. Dry bentonite shall be evenly dispersed from the panel edge to the lap line at a minimum rate of 0.25 lbs/linear foot of seam continuously along the seam or overlap areas. The dry bentonite shall be of the same chemical and materials compounds as used in the GCL.

- All dirt, gravel, or other debris shall be removed from the overlap areas.
- Seam overlap on the bottom shall placed such that the direction of the flow is from the top panel to the bottom panel to form a shingle effect.
- Seams at the base of the sideslope shall be a minimum 5 feet from the toe of slope.
- Prior to covering GCL, the CQA Engineer shall verify all exposed seam overlaps. Careful attention is required with GCLs manufactured with high moisture contents. GCL panels can shrink from exposure to heat and sunlight.

10A.9 DAMAGE AND DEFECTS

Repair damage and defects to the GCL in the following manner:

- At the judgment of the CQA Engineer, a panel which becomes seriously damaged (torn, delaminated, etc.) shall be replaced. Less serious damage shall be repaired as further defined.
- Remove rejected panels or portions of rejected panels from work area.
- All repairs shall be made by placement of a patch of the same material over the flaw or damaged area at least 1-foot beyond the repair area and seam as identified in Section 10A.8.

10A.10 REFERENCE DOCUMENTS

- Technical Specification 02772 – Geosynthetic Clay Liner (GCL) (Attachment B).
- Table 1F (Attachment A).
- Drawings: No. 7, 21, 24-26, and 30.

10B GEOMEMBRANES

10B.1 OBSERVATION AND INSPECTION

The CQA Engineer will be present on-site on a full-time basis during all components of geomembrane installation to document construction is performed in accordance with the design plans and specifications. The CQA Engineer will be responsible for the following:

- Observe and document installation of the geomembrane.
- Observe and document the installation of all subsequent layers overlying and underlying the geomembrane.
- Observe and document installation of liner protection.
- Collect samples of geomembrane for conformance testing, destructive seam sample testing.
- Obtain and record survey information.
- Maintain daily field notes regarding geomembrane installation.
- Provide photographic documentation of major construction activities.

10B.2 QUALITY CONTROL DOCUMENTATION

Prior to delivery to site, HDPE Manufacturer shall submit interface friction angle test results for critical interfaces defined in Table 1J (Attachment A) and Technical Specification 02771 - High Density Polyethylene (HDPE) Geomembrane (Attachment B). No HDPE geomembrane shall be delivered to site until approval is given by Owner.

The Manufacturer shall provide the following information on the geomembrane prior to its final acceptance for installation:

- Copy of quality control certificates issued by HDPE resin suppliers.
- Production date(s) of HDPE resin.
- Reports on tests conducted to confirm quality of HDPE resin used to manufacture geomembrane rolls assigned to considered facility. Report shall indicate compliance with requirements in Technical Specification 02771 (Attachment B) and Table 1D (Attachment A).
- Statement that no reclaimed polymer is added to resin during manufacture of actual geomembrane to be used in this project.
- Geomembrane roll production and fabrication quality control certificates indicating compliance with requirements of Technical Specification 02771 (Attachment B) and Table 1D (Attachment A).
- Installation layout identifying placement patterns and seams, both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from engineering Drawings. Layout shall be drawn to scale, shall be adequate for use as construction plan, and shall include information such as dimensions and details.
- Installation schedule as part of construction schedule.
- List of personnel performing field seaming operation, along with pertinent experience information.
- Copy of subgrade acceptance by Installer.
- Description of seaming apparatus to be used and extrudate properties.

The Installer shall provide the following information during geomembrane installation:

- Quality control documentation.

The Installer shall provide the CQA Engineer the following information after complete installation of the geomembrane:

- Geomembrane installation certification.
- Copy of warranty obtained from Manufacturer/Fabricator/Installer.

10B.3 QUALIFICATIONS

The Manufacturer shall meet the following requirements:

- A minimum 5 years continuous experience in manufacture of HDPE geomembrane rolls and/or experience totaling 2,000,000 sf of manufactured rolls for at least 10 completed facilities.
- Manufacturer shall meet the requirements listed by NSF (National Sanitation Foundation) Standard No. 54 for manufacturing HDPE.

The Fabricator (If Applicable) shall meet the following requirements:

- A minimum 5 years continuous experience in fabrication of HDPE liners or covers and/or experience totaling 2,000,000 sf of fabricated HDPE geomembrane liners or covers for at least 10 completed facilities.

The Installer shall meet the following requirements:

- A minimum 5 years continuous experience in installation of HDPE geomembrane and/or experience totaling 2,000,000 sf of installed HDPE geomembrane for at least 10 completed facilities.
- Personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one seamer shall have experience seaming a minimum of 1,000,000 sf of HDPE geomembrane using same type of seaming apparatus in use on-site. Most experienced seamer, "master seamer," shall provide direct supervision, as required, over less experienced seamers.

10B.4 DELIVERY AND STORAGE

The CQA Engineer shall visually observe the unloading and storage of the geomembrane and document the following:

- Handle geomembrane rolls or panels by appropriate means so as to cause no damage.
- Geomembrane is protected from direct sunlight and heat to prevent degradation of material and adhesion of individual whorls of roll or layers.
- Appropriate handling equipment used when moving rolled or folded geomembrane from one place to another. Instructions for moving shall be given by Manufacturer/Fabricator.

10B.5 MATERIALS/PRODUCT

The geomembrane shall consist of the following material properties:

- Be manufactured of new first-quality polyethylene resin.
- Be designed and manufactured specifically for the intended purpose.
- Geomembrane shall be double sided textured on the sidewalls on the perimeter and interior berm.

- Geomembrane shall be double sided smooth on the base of Units 1 and 2.
- Geomembrane shall meet the minimum material properties listed in Technical Specification 02771 (Attachment B) and Table 1D (Attachment A).
- Contain carbon black for ultraviolet light resistance.
- Produced to not have striations, roughness, pinholes, or bubbles on surface.
- Be produced so as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.

The Manufacturer shall geomembranes as panels or in rolls. Panel is unit area of geomembrane to be seamed in field. Two cases can be considered:

- If geomembrane is not fabricated into panels in factory, field panel is roll or portion of roll cut in field.
- If geomembrane is fabricated into factory panels, field panel is factory panel cut in field.
- Panel size shall be determined by Installer Shop Drawings showing layout and dimensions of panels in structure.

Geomembrane panel shall be labeled and identified in the following manner:

- Labels on each roll or factory panel shall identify product name, thickness of material, length, and width of roll or factory panel; Manufacturer and date manufactured; and directions to unroll material.
- Designate each roll or factory panel with panel number (identification code) consistent with layout Drawing. Panel is unit area of geomembrane to be seamed in field (e.g., one roll may be cut into several panels). Position panels on-site as shown in layout Drawings.
- Follow instructions on boxes or wrapping containing geomembrane materials to ensure panels are unrolled in proper direction for seaming.

Fabricated seams and field seams shall be completed and documented to be:

- Completed using the extrusion welding and/or fusion welding methods.
- Only apparatus which have been specifically approved by make and model shall be used.
- Proposed alternate seaming processes shall be documented and submitted to CQA Engineer for approval.
- Resin used for extrusion welding shall be produced from same resin type as geomembrane.
- Physical properties of resin used for extrusion welding shall be the same as those of resin used in manufacturing of geomembrane.

10B.6 CONFORMANCE TESTING

At minimum, the following conformance tests shall be conducted on the geomembrane at a minimum frequency of 1 per 100,000 sf per material type, unless otherwise noted, received on-site:

- Specific Gravity (ASTM D792 or D1505); 1 per 10,000 sf per material type.
- Melt Index (ASTM D1238); 1 per 100,000 sf per material type.
- Tensile Properties (ASTM D638); 1 per 100,000 sf per material type.
- Tear Resistance (ASTM D1004, Die C); 1 per 100,000 sf per material type.
- Puncture Resistance (FTM STD 101C); 1 per 100,000 sf per material type.

The following tests shall be performed on each roll received:

- Thickness (ASTM D1593 Para. 8.1.3 or ASTM D751).

The following test shall be performed at a minimum of one test per resin batch:

- Environmental Stress Cracking (ASTM D1693, modified in NSF Appendix A, condition C, 100^0 C).

Interface friction angle testing (ASTM D5231):

- Critical textured geomembrane interfaces as shown on Table 1J (Attachment A). Perform one test series (i.e., varying normal loads) per interface.

Conformance samples shall be a minimum of 3 feet long by the roll width. Mark roll identification as well as machine and cross direction accordingly on each sample. Conformance tests shall meet or exceed specified material properties in Technical Specification 02771 (Attachment B) and Tables 1D and 1J (Attachment A).

All conformance test results shall be reviewed and accepted or rejected by the CQA Engineer prior to the deployment of the geomembrane. The CQA Engineer shall examine all results from laboratory conformance testing and shall report any nonconformance to the Owner. The CQA Engineer shall be responsible for checking that all test results meet or exceed the property values listed in Table 1D (Attachment A).

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic Laboratory incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic Laboratory with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic Laboratories. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic Laboratory's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Owner.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of Owner, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

10B.7 GEOMEMBRANE DEPLOYMENT

Prior to the deployment of the geomembrane, the CQA Engineer shall document the following:

- Installer will provide in writing that surface on which geomembrane is to be installed is acceptable, free of stones and debris, and in a firm, non-yielding condition.
- After supporting soil is accepted by Installer, it shall be Installer's responsibility to indicate to Contractor any change in supporting soil condition that may require repair work. Special care must be taken to maintain prepared soil surface. Soil surface shall be observed daily to evaluate desiccation cracking. Damage to subgrade caused by this installation shall be repaired at Contractor's expense.
- Do not place geomembrane on a frozen subgrade or in area which has become softened by precipitation, i.e., unconfined compressive strength less than 1.0 tsf.

The anchor trench shall be constructed and documented to be:

- Excavate anchor trench to lines and grades shown on Drawings, prior to placement.
- Unless otherwise specified, if anchor trench will be excavated in clay soils susceptible to desiccation, no more than amount of trench required for geomembrane anchored in one day shall be excavated to minimize desiccation potential of anchor trench clay soils.
- Backfill anchor trench with clay backfill and compact to at least 90 percent of the modified Proctor maximum dry density (ASTM D1557). Document and repair damage to geomembrane while backfilling trenches.

The CQA Engineer shall observe and document the following during geomembrane panel deployment:

- Panels placed parallel to slopes.
- Place panels prior to seaming panel joints.
- Place panels one at a time and seam each panel immediately after its placement.
- Panels are not placed or seamed at ambient temperature below 0°C (32°F) or above 50°C (122°F) without performing proper procedures recommended by Manufacturer.
- Panels are not placed during precipitation, in presence of excessive moisture (e.g., fog, dew), in area of ponded water, or during excessive winds.
- Equipment used does not damage geomembrane by handling, trafficking, leakage of hydrocarbons (such as gasoline or oil), or other means.
- Personnel working on geomembrane shall not smoke, wear damaging shoes, or engage in other activities which could damage geomembrane.
- Methods used to unroll panels shall not cause scratches or crimps in geomembrane and shall not damage supporting soil.
- Method used to place panels shall minimize wrinkles (especially differential wrinkles between adjacent panels). Sufficient slack shall be incorporated into the geomembrane liner such that no tensile stresses are generated in the geomembrane or its seams during deployment or after final placement of drainage and subsequent layers. Slack left in the geomembrane shall not create wrinkles or folds that may fold over. Amount of slack shall be determined by the Engineer and Manufacturer and based upon geomembrane temperatures at deployment and construction completion.

- Place adequate loading (e.g., sand bags, tires) not likely to damage geomembrane, to prevent uplift by wind (in case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under panels).
- Direct contact with geomembrane shall be minimized; i.e., geomembrane in traffic areas shall be protected by geotextiles, extra geomembrane, or other suitable materials.
- Personnel working on geomembrane on 3H:1V slopes or greater shall wear proper fall protection.

Any damage to the geomembrane panels during placement shall be documented by the CQA Engineer with actions and repairs recorded accordingly. Damage to the geomembrane will repaired in the following manner:

- Any panel which, in judgment of Owner or CQA Engineer, becomes seriously damaged (such as torn or twisted permanently during deployment and/or displaced by wind) shall be replaced. Less serious damage shall be repaired.
- Remove rejected damaged panels or portions of rejected damaged panels from work area.

10B.8 FIELD SEAMS

10B.8.1 Seam Layout

- In general, orient seams parallel to line of maximum slope, i.e., oriented along, not across, slope.
- In corners and odd-shaped geometric locations, minimize number of field seams. No horizontal seam shall be less than 5 feet from toe of slope.

10B.8.2 Overlapping and Temporary Bonding

Deploy and stage panels to create the following:

- Overlap panels by minimum of 4 inches for fusion welding or 3 inches for extrusion welding.
- Procedure used to temporarily bond adjacent panels together shall not damage geomembrane; in particular, temperature of air at nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.
- No solvent or adhesive shall be used unless product is approved in writing by CQA Engineer or Owner (samples shall be submitted for testing and evaluation).

10B.8.3 Seam Preparation

The following shall be observed by the CQA Engineer for documentation of seam preparation:

- Clean seam area prior to seaming so that it is free of moisture, dust, dirt, debris of any kind, and foreign material.
- If seam overlap grinding is required, process shall be completed according to Manufacturer's instructions and in a way not damaging to geomembrane.
- Align seams with fewest possible number of wrinkles and "fish mouths."

10B.8.4 Seaming Equipment and Products

The approved processes for field seaming are fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted for approval to CQA Engineer prior to use. Only use apparatus specifically approved by geomembrane Manufacturer. Finished seam shall meet criteria defined in Technical Specification 02771 (Attachment B) and Table 1D (Attachment A).

10B.8.5 Fusion Welding Process

The fusion welding process shall be accomplished and maintained in the following means:

- Use automated, vehicular-mounted fusion welding apparatus.
- Equip apparatus with gauges indicating applicable temperatures and pressures.
- Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.
- Use moveable protective layer directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between sheets.
- Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.

10B.8.6 Extrusion Welding Process:

The extrusion welding process shall be accomplished and maintained in the following means:

- Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.
- Provide documentation of extrudate to CQA Engineer or Owner, and certify that extrudate is compatible with specifications and is comprised of same resin as geomembrane.
- Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.
- Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from barrel. When extruder is stopped, purge barrel of all heat-degraded extrudate.
- Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.

10B.8.7 Weather Conditions

The following seaming criteria shall be applied:

- No seaming shall be attempted below 5°C (40°F) or above 40°C (104°F) without proper procedures from Manufacturer.
- Between 5°C (40°F) and 10°C (50°F), seaming shall be possible if geomembrane is preheated by either sun or hot air device, and if there is not excessive cooling resulting from wind.
- Above 10°C (50°F), no preheating shall be required.
- Geomembrane shall be dry and protected from wind damage.
- In the event of seaming below 5°C (40°F) or above 40°C (104°F), certify in writing that low-temperature or high-temperature seaming procedure does not cause any physical or

chemical modification to geomembrane that will generate any short- or long-term damage to geomembrane.

10B.8.8 General Seaming Procedures

- For fusion welding, provide temporary sacrificial or protective layer of plastic placed directly below each overlap of geomembrane to be seamed. This is to prevent moisture build-up between panels to be welded.
- Seaming shall extend to outside edge of panels to be placed in anchor trench.
- If required, provide firm substrate by using flat board, conveyor belt, or similar hard surface directly under seam overlap to achieve proper support.
- Cut "fish mouths" or wrinkles at seam overlaps along ridge of wrinkle in order to achieve flat overlap. Seam cut "fish mouths" or wrinkles. Patch any portion where overlap is inadequate with oval or round patch of same geomembrane extending a minimum of 6 inches beyond cut in each direction.

10B.8.9 Trial Seams

The CQA Engineer shall observe the trail weld process. Trial welds shall be prepared and documented for the following:

- Use fragment pieces of geomembrane to confirm seaming conditions are adequate.
- Perform trial seams at the beginning of each seaming period, at CQA Engineer's or Owner's discretion, after equipment repairs or major adjustments, wide changes in geomembrane temperature, and at least once every 4 hours for each seaming apparatus used that day.
- Each seamer shall make at least one trial seam each day.
- Trial seams shall be 3 feet long by 1 foot wide with seam centered lengthwise.
- Cut by standard cutting die, three specimens, two for peel from with one from each end of sample and one randomly from across the trial sample for shear. Each specimen shall be 1 inch wide from each trial sample.
- Test seams in shear and peel using digital field tensiometer.
- Test specimen shall not fail in seam as defined in Table 1D (Attachment A).
- If additional trial seams fail, seaming apparatus or seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive successful full trial seams are achieved.

10B.8.10 Nondestructive Seam Continuity Testing

The following methods and documentation are to performed on all seams:

- Nondestructively test field seams over their full length using vacuum test unit or air pressure (if double fusion process). Continuity testing shall be done as seaming work progresses, not at completion of field seaming.
- Complete required repairs.
- Apply the following procedures to locations where seams cannot be nondestructively tested, as determined by CQA Engineer or Owner:

  a. Install cap-stripped seams with same geomembrane where possible.

b. If seam is accessible to testing equipment prior to final installation, seam shall be nondestructively tested prior to final installation.
c. If seam cannot be tested prior to final installation, seaming and cap-stripping operations shall be observed by CQA Engineer or Owner for uniformity and completeness.

10B.8.11 Vacuum Testing

The following equipment shall be used and documented for vacuum testing:

- Vacuum chamber.
- Vacuum pump.
- Vacuum gauge calibrated within 12 months prior to test date.
- Foaming solution.

The following process shall be used to test the seam:

- Energize vacuum pump and reduce tank pressure to approximately 4 to 8 psi.
- Wet strip of geomembrane approximately twice the width and length of vacuum chamber with foaming solution.
- Place box over wetted area.
- Close vent valve and open vacuum valve.
- Ensure leak-tight seal is created.
- For period of not less than 10 seconds, examine geomembrane through viewing window for presence of bubbles.
- If no bubble(s) appear after 10 seconds, close vacuum valve and open vent valve, move box over next adjoining area with minimum 2-inch overlap, and repeat process.
- Mark areas where bubbles appear, and then repair those areas.

10B.8.12 Air Pressure Testing

The following equipment shall be used and documented for air pressure testing of double-tracked fusion welds:

- Air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a minimum pressure of 27 psi for 60-mil thick geomembrane.
- Rubber hose with fittings and connections.
- Sharp hollow needle or other approved pressure feed device.

The following procedure shall be followed for air pressure testing:

- Seal both ends of seam to be tested.
- Insert needle or other approved pressure feed device into air channel created by fusion weld. Place protective cushion between air pump and geomembrane.
- Energize air pump to a minimum pressure of 27 psi for 60-mil thick geomembrane, close valve, and sustain pressure for approximately 5 minutes.
- If pressure loss of more than 3 psi for 60-mil thick geomembrane is noticed, locate faulty area and repair.
- At end of test, cut end of seam opposite pressure feed device and watch gauge pressure drop to zero, then seal.

- If gauge pressure does not return to zero, check for air channel obstruction and repeat air pressure test.
- If gauge pressure does not drop to zero after repeating air pressure testing, then seam shall be tested with vacuum box.
- Remove needle or other approved pressure feed device and seal.

10B.8.13 Destructive Seam Strength Testing

10B.8.13.1 Test Frequency

The following test location and frequency shall be documented:

- Conduct a minimum of one test per 500 feet of seam length.
- Additional test locations may be determined during seaming at CQA Engineer's or Owner's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.
- Installer shall not be informed in advance of locations where seam samples will be taken.

10B.8.13.2 Sample Procedure

The following sample procedure shall be used for destructive strength testing:

- Cut samples as seaming progresses in order to obtain laboratory test results prior to completion of geomembrane installation.
- Number each sample and identify sample number and location on panel layout Drawing.
- Repair holes in geomembrane resulting from destructive seam sampling immediately.
- Test continuity of new seams in repaired area according to Nondestructive Seam Continuity Testing.

10B.8.13.3 Sample Size

The following sample size shall be observed and documented:

- Cut samples 16 inches wide by 44 inches long with seam centered lengthwise.
- Punch one 1-inch wide strip from each end of sample and test using digital field tensiometer for peel and shear. Tested specimen shall not fail in seam.
- Cut remaining sample into three equal parts (minimum 13 inches each) and distribute as follows:

  a. One portion to Installer for laboratory testing, 16 inches by 13 inches.
  b. One portion for independent laboratory testing, 16 inches by 16 inches.
  c. One portion to Owner for archive storage, 16 inches by 13 inches.

10B.8.13.4 Laboratory Testing

The Geosynthetic Laboratory shall submit test results to CQA Engineer or Owner no more than 48 hours after laboratory receives samples.

Each destructive seam sample shall be tested for "seam strength" and "peel adhesion" according to ASTM D4437. Minimum acceptable values are indicated in Technical Specifications 02771 (Attachment B) and Table 1D (Attachment A). Test at least five replicate specimens for each test method. To be acceptable, four out of five replicates shall pass seam strength and peel adhesion criteria in Technical Specifications 02771 (Attachment B) and Table 1D (Attachment A).

10B.8.13.5 Destructive Test Seam Failure

Apply the following procedures whenever seam sample fails field destructive test:

- Reconstruct seam between any two passed test locations; or
- Retrace welding path to intermediate location, at 10 feet minimum from location of failed test in each direction, and take small samples for additional field tests. If additional samples pass test, then seam shall be reconstructed between those locations on either side of original failed location. If any sample fails, the process shall be repeated.

In any case, acceptable seams shall be bounded by two passed test locations (i.e., above procedure shall be followed in both directions from original failed location), and one sample for laboratory destructive testing shall be taken within reconstructed area.

In event that seam sample fails laboratory destructive test (whether conducted by independent laboratory or by Installer's laboratory), then above procedures shall be followed considering laboratory tests exclusively. Because final seam must be bounded by two passed test locations, it may then be necessary to take one or more samples for laboratory testing in addition to one required in reconstructed seam area.

10B.9 DEFECTS AND REPAIRS

Apply the following procedures for defect and repairs:

- Identification: Broom or wash geomembrane if amount of dust or mud inhibits inspection.
- Evaluation: Nondestructively test each suspect location in seam and nonseam areas. Repair each location which fails nondestructive testing.
- Repair Procedures:

  a. Repair defective seams by reconstruction.
  b. Repair excessive wrinkles by cutting and seaming.
  c. Repair tears or pinholes by seaming or patching.
  d. Repair blisters, larger holes, undispersed raw materials, and contamination by foreign matter by patches.
  e. Surfaces of geomembrane to be patched shall be abraded no more than 1 hour prior to repair.
  f. Seams used in repairs shall be approved extrusion or fusion welded seams and may be subjected to same destructive test procedure as outlined for other seams.
  g. Patches shall be round or oval in shape, made of same geomembrane, extend a minimum of 6 inches beyond edge of defects, and applied using approved methods only.

10B.10 SEAM RECONSTRUCTION PROCEDURES

- Fusion Welds: Cut out existing seam and weld in replacement strip, or extrusion weld if there is sufficient flap width at edge of previous fusion weld.
- Extrusion Welds: Grind and reweld small seam sections, or cap or top for large seam sections.

10B.11 VERIFICATION OF REPAIRS

The following procedures shall be completed in verification of repair completion:

a. Test each repair nondestructively.
b. Repairs passing nondestructive test shall be taken as indication of adequate repair.
c. Failed tests indicate repair shall be redone and retested until passing test results.

10B.12 GEOMEMBRANE ACCEPTANCE

Installer shall retain ownership and responsibility for geomembrane until acceptance by Owner. Geomembrane installation shall be accepted by Owner when:

a. Installation is finished.
b. Documentation of installation is completed, including inspector's final report and reporting of all geomembrane test results.
c. Confirmation of adequacy of field seams and repairs, including associated testing, is complete.

10B.13 MATERIALS IN CONTACT WITH GEOMEMBRANE

Install materials in contact with geomembrane surfaces carefully to minimize damage potential. Geotextile section loosely placed may be used as protection for geomembrane, if approved by Owner's representative.

Clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane to each appurtenance shall have lifespan equal to or exceeding geomembranes'.

10B.13.1 Pipes and Other Appurtenances

- Install geomembrane around appurtenances, such as pipes, protruding through geomembrane as shown in Drawings.
- Unless otherwise specified, initially install geomembrane sleeve or shield around each appurtenance prior to geomembrane installation.
- After material is placed and seamed, complete final field seam connection between appurtenance sleeve or shield and geomembrane. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geomembrane can be accommodated.
- Use extreme care while seaming around appurtenances, because both nondestructive and destructive seam testing might not be feasible.
- Do not damage geomembrane while making connections to appurtenances.

10B.13.2 Cover Materials

- Do not place cover materials on geomembrane if ambient temperature is below 5°C (40°F) or above 40°C (104°F) without proper procedure recommendations from Manufacturer.
- Vehicle traffic with a contact pressure greater than 8 psi shall not be permitted unless material over the geomembrane is a minimum of 3 feet.
- Do not drive equipment used for placing cover material directly on geomembrane.
- Place cover material in such manner that geomembrane damage is unlikely.
- Place geonet geocomposite and/or geotextile overlying HDPE geomembrane liner within 30 days of completing seam testing of geomembrane.

10B.14 REFERENCE DOCUMENTS

- Technical Specification 02771 – High Density Polyethylene Geomembrane (Attachment B).
- Tables 1D and 1J (Attachment A).
- Drawings: No. 7, 21, 24-26, and 30.

10C GEOCOMPOSITE

10C.1 OBSERVATION AND INSPECTION

The CQA Engineer will be present on-site on a full-time basis during all components of geocomposite installation to document construction is performed in accordance with the design plans and specifications. The CQA Engineer will be responsible for the following:

- Observe and document installation of the geocomposite.
- Observe and document the installation of all subsequent layers overlying and underlying the geocomposite.
- Observe and document installation of liner protection.
- Collect samples of geocomposite for conformance testing.
- Obtain and record survey information.
- Maintain daily field notes regarding geocomposite installation.
- Provide photographic documentation of major construction activities.

10C.2 QUALITY CONTROL DOCUMENTATION

Prior to the delivery to Site, the Contractor shall perform the following activities pertaining to the geocomposite:

- Geocomposite samples and list of minimum property values, including certified test results. Material properties shall be in conformance with those defined on Table 1E (Attachment A) and Technical Specification 02775 (Attachment B). Any deviation shall be documented.
- Thread properties if thread is used for sewing seams.
- A list of completed facilities for which Installer has installed a minimum of 1,000,000 sf of geocomposite.
- Copy of warranty obtained from Manufacturer or Installer.
- Written documentation that the geocomposite has been installed according to the design plans and specifications and that in-place materials meet generally accepted standards of practice.
- Prior to delivery to site, samples of the geocomposite shall be submitted for interface friction angle and transmissivity conformance testing listed in Technical Specification 02275 (Attachment B) and Table 1E (Attachment A). No geocomposite shall be delivered to site until approval is given by Owner.

10C.3 QUALIFICATIONS

The Manufacturer shall meet the following requirements:

- At least 5 years continuous experience in manufacturing geonets and geotextiles and/or experience totaling a minimum of 2,000,000 sf of geonet and geotextile manufacturing.

The Installer shall meet the following requirements:

- Installation supervisor shall remain on-site and be in responsible charge throughout geocomposite installation. Installation supervisor shall have installed or supervised installation of a minimum of 1,000,000 sf of geocomposite.

Geocomposite must be meet the following qualifications:

- Free of defects, rips, holes, or flaws.
- Manufactured in widths and lengths that will permit installation of geocomposite with as few laps as possible.
- Wrapped in relatively impermeable and opaque protective covers during shipment and storage.
- Marked with Manufacturer's name, product identification, lot number, roll number and roll dimensions.
- Storage area shall be such that geocomposite is protected from mud, dirt, dust, debris, moisture, and exposure to ultraviolet (UV) light and heat.

10C.4 DELIVERY AND STORAGE

- Transportation of geocomposite is responsibility of Manufacturer, who shall be liable for all damages to geocomposite prior to and during transportation to site.
- Handling, storage, and care of geocomposite on-site is responsibility of Installer prior to, during, and after geocomposite installation. Owner shall provide adequate storage space on-site. Installer shall be liable for all damages to geocomposite incurred prior to final acceptance of installation by Owner, except for those due to negligent actions on part of Owner.
- Manufacturer and/or Installer shall retain ownership of geocomposite until installation is accepted by Owner.

10C.5 MATERIALS/PRODUCT

10C.5.1 Geotextile

Provide a nonwoven product for the geotextile portions of the geocomposite comprised of polyester or polypropylene meeting the minimum average roll values listed in Technical Specification 02775 (Attachment B).

10C.5.2 Geonet

Provide a product for the geonet portion of the geocomposite comprised of high-density polyethylene (HDPE). Manufacture by extruding two sets of strands to form a three-dimensional structure to provide plane flow, meeting the minimum average roll values listed in Technical Specification 02775 (Attachment B).

10C.5.3 Geocomposite

- Manufactured by heat bonding the geotextile to the geonet on both sides. No burn through geotextiles nor glue or adhesive shall be permitted.
- Minimum peel strength of 2 psi for bond between the geotextiles and the geonet (ASTM D413).

10C.6 PLACEMENT AND HANDLING

- Handle all geocomposite in such a manner as to ensure it is not damaged in any way.
- Install with the machine direction parallel to the slope.
- Completely cover geocomposite with overlying layer within 14 days of removing protective wrapping from geocomposite.
- Weight geocomposite with sandbags or equivalent in the presence of wind. Such sandbags installed during placement shall remain until replaced with earthen cover material.
- Cut using an approved cutter only.
- Take care to protect geomembrane from damage which could be caused by cutting of geocomposites.
- During placement, do not entrap stones, excessive dust, or moisture in geocomposite that could hamper subsequent seaming. If geocomposite is not free of debris and soil prior to installation, clean geocomposite prior to installation.
- Examine geocomposite over entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present.
- Remove any foreign objects, or replace geocomposite.
- Take precautions against "snowblindness" of personnel if light or white-colored geotextile is used for the geocomposite.
- Do not weld or tack weld geocomposite to the underlying geomembrane.
- Personnel working on geonet geocomposite on 2H:1V or steeper slopes shall wear proper fall protection.

10C.7 CONFORMANCE TESTING

Samples of geocomposite delivered to site shall be collected for testing to confirm conformance with the final produced geocomposite product. At a minimum, two samples from on-site geocomposite shall be tested as a unit for the following:

- Transmissivity (ASTM D4716).

Conformance samples shall be a minimum of 3 feet long by the roll width. Mark roll identification as well as machine and cross direction accordingly on each sample. Conformance tests shall meet or exceed specified material properties in Technical Specification 02775 (Attachment B) and Table 1E (Attachment A).

All conformance test results shall be reviewed and accepted or rejected by the CQA Engineer prior to the deployment of the geocomposite. The CQA Engineer shall examine all results from laboratory conformance testing and shall report any nonconformance to the Owner. The CQA Engineer shall be responsible for checking that all test results meet or exceed the property values listed in Table 1E (Attachment A).

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic Laboratory incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic Laboratory with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic Laboratories. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic Laboratory's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Owner.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of Owner, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

10C.8 SEAMS AND OVERLAPS

- Overlap the geonet portion of geocomposite a minimum of 6 inches along roll edges and 6 inches at roll ends.
- Join geonet by colored plastic ties every 5 feet along the roll length and every 6 inches at roll ends.
- Overlap the geotextile portion of geocomposite a minimum of 3 inches above and below geonet.
- Continuously sew geotextile above geonet on sideslopes.
- Use polymeric thread with chemical resistance properties equal to or exceeding those of geotextile for any sewing.
- No horizontal seams shall be allowed on the sidewalls (seams shall be along, not across slope).

10C.9 REPAIRS

- Repair any holes or tears in geotextile as follows:

  a. Thermally bond a patch made from same geotextile into place. Patch shall extend a minimum of 12 inches beyond edge of defect.
  b. Should any tear exceed 10 percent of width of roll on a sideslope, that roll shall be removed from slope and replaced.

- Repair any holes or tears in geonet as follows:

  a. Place a patch made from same geonet extending a minimum of 12 inches beyond edge of defect.
  b. Tie patch to underlying geonet using ties spaced a maximum of 6 inches apart.
  c. Remove and replace entire length of geonet on sideslopes if holes or tears extend a distance greater than 50 percent of geonet width.

10C.10 PLACEMENT OF EARTHEN MATERIALS OVER GEOTEXTILE

- Place all cover materials located on top of geocomposite in such a manner as to ensure:

    a. No damage of geocomposite.
    b. Minimal slippage of geocomposite on underlying layers.
    c. No excess tensile stresses in geocomposite.
    d. Contact pressure on material over geocomposite not exceeding 8 psi.

- Do not place cover material over geocomposite until anchorage is completed as shown on Drawings.

- Place cover material over geocomposite as follows:

    a. A minimum of 12 inches of earthen material shall be in place before vehicles shall be permitted to cross over geocomposite.
    b. Push cover material out over geocomposite ahead of equipment in one 12-inch thick lift.
    c. Place cover material on sideslopes beginning at the toe of slope and proceed upslope to top of slope.
    d. Observe advancing lift to assure adequate thickness of material is in place.
    e. Equipment used to install cover material over geocomposite shall have a maximum contact pressure of 8 psi on earthen material.
    f. Vehicle traffic with a contact pressure greater than 8 psi shall not be permitted unless material thickness over geocomposite is a minimum of 3 feet.

12C.11 REFERENCE DOCUMENTS

- Technical Specification 02775 – Geonet Geocomposite (Attachment B).
- Table 1E (Attachment A).
- Drawings: No. 7, 21, 24-26, and 30.

10D GEOTEXTILE (CUSHION)

10D.1 OBSERVATION AND INSPECTION

The CQA Engineer will be present on-site on a full-time basis during all components of geotextile cushion installation to document construction is performed in accordance with the design plans and specifications. The CQA Engineer will be responsible for the following:

- Observe and document installation of the geotextile.
- Observe and document the installation of all subsequent layers overlying and underlying the geotextile.
- Observe and document installation of liner protection.
- Collect samples of geotextile for conformance testing.
- Obtain and record survey information.
- Maintain daily field notes regarding geomembrane installation.
- Provide photographic documentation of major construction activities.

10D.2 QUALITY CONTROL DOCUMENTATION

Prior to the delivery to Site, the Contractor shall perform the following activities pertaining to the geotextile:

- Geotextile samples and list of minimum property values, including certified test results. Material properties shall be in conformance with those defined in Technical Specification 02774 (Attachment B) and Table 1G (Attachment A). Any deviation shall be documented.
- Thread properties.
- A list of completed facilities for which Installer has installed a minimum of 1,000,000 sf of geotextile.
- Copy of warranty obtained from Manufacturer or Installer.

10D.3 QUALIFICATIONS

The Manufacturer shall meet the following minimum requirements:

- At least 5 years continuous experience in manufacturing of geotextiles and/or experience totaling a minimum of 2,000,000 sf of geotextile manufacture.

The Installer shall meet the following minimum requirements:

- Supervisor shall have experience installing or supervising a minimum of 1,000,000 sf of geotextile. Supervisor shall remain on-site throughout geotextile installation.

The geotextile to be used as the primary cushion geotextile overlying the primary geomembrane shall meet the following:

- Free of defects, rips, holes, or flaws.

- Manufactured in widths and lengths that will permit installation of geotextile with as few laps as possible.
- Wrapped in relatively impermeable and opaque protective covers during shipment and storage.
- Marked with Manufacturer's name, product identification, lot number, roll number, and roll dimensions.
- Stored in an area protected from mud, dirt, dust, debris, moisture, and exposure to ultraviolet (UV) light and heat.

10D.4 DELIVERY AND STORAGE

- Transportation of geotextile is responsibility of Manufacturer, who shall be liable for all damages to geotextile prior to and during transportation to site.
- Handling, storage, and care of geotextile on-site is responsibility of Installer prior to, during, and after geotextile installation. Owner will provide adequate storage space on-site. Installer shall be liable for all damages to geotextile incurred prior to final acceptance of installation by Owner, except for those due to negligent actions on part of Owner.
- Manufacturer and/or Installer shall retain ownership of geotextile until installation is accepted by Owner.

10D.5 MATERIALS/PRODUCTS

The geotextile shall be a nonwoven product comprised of polyester or polypropylene. Geotextile properties shall meet minimum average roll values listed in Technical Specification 02274 and Table 1G.

Securing pins, if used, shall be 3/16-inch in diameter, of steel, pointed at one end, and fabricated with a head to retain a steel washer having an outside diameter of no less than 1.5 inches. No pin shall be placed where there is a possibility of it puncturing or otherwise damaging geomembrane.

10D.6 PLACEMENT AND HANDLING

- Handle all geotextiles in such a manner as to ensure they are not damaged in any way.
- Completely cover with a minimum 12-inch thick layer of earthen material within 14 days of removing protective wrapping from geotextile.
- Securely anchor geotextiles on sidewalls in anchor trench (if required) and then roll down slope in such a manner as to continually hold geotextile sheet in sufficient tension to preclude folds and wrinkles.
- Weight geotextiles with sandbags or equivalent. In the presence of wind, sandbags shall be installed during placement and shall remain until replaced with earthen cover material.
- Cut using an approved geotextile cutter, only.
- Protect geomembrane from damage which could be caused by cutting of geotextiles.
- Do not entrap stones, excessive dust, or moisture in geotextile that could damage geomembrane or hamper subsequent seaming.
- Examine entire surface, after installation, for potentially harmful foreign objects, such as needles.
- Remove any foreign objects or replace geotextile.
- Take precautions against "snowblindness" of personnel if white or light-colored geotextiles are used.

10D.7 CONFORMANCE TESTING

At a minimum, the following conformance tests shall be conducted on the geotextile at a minimum frequency of 100,000 sf or one per lot; whichever is less.

- Wide-Width Tensile Strength (ASTM D4595).
- Grab Tensile Strength (ASTM D4632).
- Trapezoidal Tear Strength (ASTM D4533).
- Puncture Strength (ASTM D4833).

Conformance samples shall be a minimum of 3 feet long by the roll width and do not include the first 3 feet. Mark roll identification as well as machine and cross direction accordingly on each sample. Conformance tests shall meet or exceed specified material properties in Technical Specification 02774 (Attachment B) and Table 1G (Attachment A).

All conformance test results shall be reviewed and accepted or rejected by the CQA Engineer prior to the deployment of the geotextile. The CQA Engineer shall examine all results from laboratory conformance testing and shall report any nonconformance to the Owner. The CQA Engineer shall be responsible for checking that all test results meet or exceed the property values listed in Table 1G (Attachment A).

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic Laboratory incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic Laboratory with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic Laboratories. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic Laboratory's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Owner.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of Owner, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

10D.8 SEAMS AND OVERLAPS

- Continuously sew geotextile.
- Overlap geotextiles 6 inches prior to seaming.
- No horizontal seams shall be allowed on sidewalls. Seams shall be along, not across slope.
- Use polymeric thread for sewing with chemical resistance properties equal to or exceeding those of geotextile.

10D.9 REPAIR

- Repair any holes or tears in geotextile as follows:

  a. Double seam a patch made from same geotextile into place (with each seam 1/4-inch to 3/4-inch apart, and no closer than 1 inch from any edge). Patch shall extend a minimum of 12 inches beyond edge of defect.
  b. Should any tear exceed 10 percent of the width of roll, that roll shall be removed and replaced.

10D.10 PLACEMENT OF EARTHEN MATERIALS OVER GEOTEXTILE

- Place all earthen materials, such as granular drainage blanket, located on top of geotextile in such a manner as to ensure:

  a. No damage of geotextile.
  b. Minimal slippage of geotextile on underlying layers.
  c. No excess tensile stresses in geotextile.
  d. Contact pressure on material over geotextile not exceeding 8 psi.

- Do not place earthen material over geotextile along sidewalls until anchorage (if necessary) is completed as shown on Drawings.

10D.11 CREST ANCHORAGE SYSTEM

- Excavate anchor trench to lines and grades shown on Drawings prior to geotextile placement on sidewalls.
- Unless otherwise specified, if anchor trench will be excavated in clay soils susceptible to desiccation, no more than amount of trench required for geotextile anchored in one day shall be excavated to minimize desiccation potential of anchor trench soils.
- Backfilling of anchor trench:

  a. Backfill anchor trench with clay soils and compact to at least 90 percent of modified Proctor maximum dry density (ASTM D 1557).
  b. Take care when backfilling trenches to prevent damage to geotextile.

- Place and compact cover soil to at least 90 percent of the modified Proctor maximum dry density (ASTM D1557).
- Place granular drainage blanket over geotextile as follows:

  a. A minimum of 12 inches of granular drainage blanket shall be in place before vehicles shall be permitted to cross over geotextile.
  b. Push granular drainage layer out over geotextile ahead of equipment in two 12-inch thick lift.
  c. Observe advancing lift to assure adequate thickness of material is in place.
  d. Equipment used to install granular drainage layer over geotextile shall have a maximum contact pressure of 8 psi on earthen material.

e. Vehicle traffic with a contact pressure greater than 8 psi shall not be permitted unless material thickness over geotextile is a minimum of 3 feet.

10D.12 REFERENCE DOCUMENTS

- Technical Specification 02774 – Geotextile Cushion (Attachment B).
- Table 1G (Attachment A).
- Drawings: No. 7, 21, 24-26, and 30.

~~The CQA Engineer will be present on-site on a full-time basis during construction to document that construction of the geosynthetic liner is performed in accordance with the design plans and specifications. The CQA Engineer will be responsible for the following items:~~

- ~~Inspect base grade surface to be free from sharp objects prior to placing the GCL.~~
- ~~Observe and document installation of GCL.~~
- ~~Observe and document installation of secondary geomembrane.~~
- ~~Observe and document installation of geonet composite.~~
- ~~Observe and document installation of primary geomembrane.~~
- ~~Observe and document installation of geotextile cushion on the base and geonet composite on the sidewalls.~~
- ~~Collect samples of geosynthetic materials at frequencies shown in Table 1 of this CQAP.~~
- ~~Observe and document installation of liner protection.~~
- ~~Obtain and record survey information.~~
- ~~Maintain daily field notes regarding project construction.~~
- ~~Provide photographic documentation of major construction activities.~~

~~10.2 CONSTRUCTION TESTING~~

~~Both in field and laboratory testing will be performed to document materials used and method of placement for the geosynthetic liner system.~~

~~10.2.1 Base Grade Preparation~~

~~Refer to Section 7 of this CQAP for base grade preparation.~~

~~10.2.2 Geosynthetic Clay Liner~~

~~The Geosynthetic Clay Liner (GCL) will satisfy the criteria in the specifications.~~

~~In field and laboratory testing will be performed at the frequencies shown in Table 1 of this CQAP. Testing will include:~~

- ~~Bentonite Mass/Area (ASTM D5993)~~
- ~~GCL Grab Tensile (ASTM D4632)~~
- ~~GCL Peel Strength (ASTM D4632)~~
- ~~Interface friction (ASTM D5321)~~

~~10.2.3 Secondary Geomembrane Layer~~

~~The geomembrane will consist of 60 mil HDPE satisfying the criteria in the specifications.~~

~~In-field and laboratory testing will be performed at the frequencies shown in Table 1 of this CQAP. Testing will include:~~

~~-Thickness (ASTM D5199)~~
~~-Specific Gravity (ASTM D792 or D1505)~~
~~-Melt Index (ASTM D1238)~~
~~-Tensile Properties (ASTM D638)~~
~~-Environmental Stress Crack Resistance (ASTM D1693 or D5397)~~
~~-Seam Peel and Shear (ASTM D4437)~~
~~-Air Pressure Test of Seams (GRI GM6)~~
~~-Interface Friction with material above and below (ASTM D5321)~~

~~10.2.4 Geonet Composite~~

~~The leak detection drainage layer and the primary drainage layer on the sidewall will consist of a geonet constructed of high density polyethylene satisfying the criteria in the specifications. Laboratory testing will be performed at the frequencies shown in Table 1 of this CQAP. Testing will include:~~

~~Geotextile~~

~~-Apparent Opening Size (ASTM D4751)~~
~~-Transmissivity (ASTM D4716)~~

~~Geonet~~

~~-Transmissivity (ASTM D4716)~~

~~10.2.5 Primary Geomembrane~~

~~The geomembrane will consist of 60 mil HDPE satisfying the criteria in the specifications.~~

~~In-field and laboratory testing will be performed at the frequencies shown in Table 1 of this CQAP. Testing will include:~~

~~-Thickness (ASTM D5199)~~
~~-Specific Gravity (ASTM D792 or D1505)~~
~~-Melt Index (ASTM D1238)~~
~~-Tensile Properties (ASTM D638)~~
~~-Environmental Stress Crack Resistance (ASTM D1693 or D5397)~~
~~-Seam Peel and Shear (ASTM D4437)~~
~~-Air Pressure Test of Seams (GRI GM6)~~
~~-Interface Friction with material above and below (ASTM D5321)~~

~~10.2.6 Geotextile Cushion~~

~~The geotextile layer will consist of a nonwoven needle punched geotextile constructed of either polypropylene or polyester satisfying the criteria in the specifications. In field and laboratory testing will be performed at the frequencies shown in Table 1 of this CQAP. Testing will include:~~

- ~~Mass/Unit Area (ASTM D5261)~~
- ~~Grab Strength (ASTM D4632)~~
- ~~Elongation (ASTM D4632)~~
- ~~Trapezoidal Tear (ASTM D4533)~~
- ~~Puncture Strength (ASTM D4833)~~
- ~~Burst Strength (ASTM D3786)~~

~~10.3 FAILING TESTS OR MATERIALS~~

~~If failing laboratory or field tests occur for any of the geosynthetic liner components, the area will be reworked and retested to achieve passing tests. If the material is incapable of achieving passing results, the material will be removed and replaced with acceptable material (if seam test fails, replace 10 feet in either direction).~~

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11.0 LEAK DETECTION AND LEACHATE COLLECTION SYSTEM

The Leak Detection and Leachate Collection systems consists of the following components:

- Collection piping, including:
  - Perforated pipes (6-inch diameter, Schedule 120 PVC)
  - Sideslope non-perforated clean-out risers (6-inch diameter, Schedule 120 PVC)

- Drainage layer, including:
  - Granular drainage layer
  - Geonet composite – leak detection system and sidewall leachate collection system (discussed in Section 10 of this CQAP)

- Leachate collection sumps, including:
  - Pumps
  - Sideslope Risers (18-inch diameter HDPE SDR11)

- Leachate conveyance system, including:
  - Forcemain (3-inch diameter HDPE SDR11)
  - Pipe connection manholes
  - Leachate collection manhole (MH01 and MH02)

- Electrical and control systems

11.1 OBSERVATION AND INSPECTION

The CQA Engineer will be present on-site on a full-time basis during construction to document that construction of the Leak Detection and Leachate Collection systems are performed in accordance with the design plans and specifications. The CQA Engineer will be responsible for the following items:

- Observe installation of the leak detection and leachate collection system collection pipes and drainage material.
- Observe horizontal piping installations and obtain leak detection and leachate collection pipe inverts and location information.
- Observe pressure testing of piping systems and leak detection testing of sumps.
- Observe and document excavations and backfill of pipe trenches, and sump and manhole excavations, including restoration of any CAMU surface areas disturbed during construction.
- Observe installation of the sump pumps.
- Observe installation of pipe connection and leachate collection manholes.
- Observe installation of the electrical and control systems
- Survey pertinent system inverts and elevations.
- Maintain daily field notes and testing records regarding project construction.
- Observe working condition of all leak detection and leachate collection system components.
- Provide photographic documentation of major construction activities.

11.2 CONSTRUCTION TESTING

In-field testing will be performed to document that installation and materials used are in conformance with the design drawings and specifications. The Earthwork Contractor is responsible for selecting materials and components that meet project requirements. The Earthwork Contractor will submit manufacturers' information regarding selected materials for approval prior to installation. Specific testing and sampling activities for the Leak Detection and Leachate Collection Systems are discussed below. In field and laboratory testing will be performed at the frequency shown in Table 1C (Attachment A) of this CQAP.

11.2.1 Granular Drainage Layer

The granular drainage layer will consist of a 2-foot thick layer of graded granular material satisfying the grain size distribution in the specifications. The material, used for granular drainage blankets will be rounded, free from sharp edges, and noncalcarious.

In field and laboratory testing will be performed at the frequency shown in Table 1C (Attachment A) of this CQAP. Testing will include:

- Grain-Size Analysis (ASTM D422; sieve)
- Survey on a 100-foot grid

11.2.2 Sidewall Geonet Composite

Refer to Section 10, Liner System of this CQAP.

11.2.3 Pipe Bedding and Trench Backfill Material

Pipe bedding and backfill materials will conform with the specifications and placement will be documented by the CQA Engineer.

In field and laboratory testing will be performed at the frequency shown in Table 1C (Attachment A) of this CQAP. Testing will include:

- Grain Size Analyses (ASTM D422; sieve)

11.2.4 Collection and Conveyance Pipes

The leachate forcemain pipe will be air-pressure tested by the Earthwork Contractor after installation to document integrity of the pipe and pipe connections. Air-pressure testing will be performed in accordance with the specifications and documented by the CQA Engineer. Individual pipe sections will be pressure tested during construction to confirm connection methods. To allow for liquids drainage and removal of leachate formed in the pipes, the headers will be installed with a minimum slope of 0.5 percent. Construction will be documented by the CQA Engineer. Refer to Drawings D8 and D25 through D30 of the COLDR for the header pipe locations and details, respectively. The location and elevations of the pipe systems, including inverts, junctions, bends, etc., will be located by survey.

11.2.5 Sumps

Leak detection and leachate collection system collection sumps are constructed by excavating to the dimensions shown on Drawings D27 and D28, respectively of the COLDR. The integrity of the collection sumps will be tested using a 24-hour leak detection test. Leak detection testing will be performed in accordance with the specifications and documented by the CQA Engineer.

11.2.6 Pumps

The leak detection and leachate collection system sump pumps and manhole pumps will be installed based on manufacturers' and suppliers' requirements. The pumps and controls will be observed to be in working order upon completion of installation. Electrical and control system components requirements are described in the specifications.

11.2.7 Collection Manholes

The leak detection and leachate collection system collection manholes (MH01 and MH02) are constructed of pre-cast concrete. The manholes will be wrapped in GCL as a secondary containment system. Construction will be documented by the CQA Engineer. Refer to Drawing D31 of the COLDR for manhole details.

11.2.8 Pipe Connection Manholes

Leachate extracted from Unit 1 (leachate collection and leak detection systems) travels through, and is metered in, pipe connection manholes CM1-1 and CM1-2, which are located along the west edge of Unit 1. Leachate extracted from Unit 2 travels through, and is metered in, pipe connection manholes CM2-1 and CM2-2, which are located along the east edge of Unit 2. The pipe connection manholes consist of a buried PE box containing pipe connections, flow meters, and sample ports. Construction will be documented by the CQA Engineer. Refer to Drawing D30 of the COLDR for manhole details.

11.2.9 Electrical and Controls

The electrical service to the CAMU leak detection and leachate collection system is 480-volt, 3-phase, 4-wire power and will extend from existing service near the former Select Beverage facility to the CAMU leak detection and leachate collection system. Electrical service includes a service entrance, utility meter, main disconnect, transformers, electrical and control panels, and related equipment. Control wires will run to each sump location and the leachate collection manholes. Construction will be documented by the CQA Engineer.

The leak detection and leachate collection system controls will be installed based on manufacturers' and suppliers' requirements. The controls will be observed to be in working order upon completion of installation. Electrical and control system components requirements are described in the specifications.

11.3 FAILING TESTS OR MATERIALS

If failing field tests occur for any of the pressure tested components of the leak detection/leachate collection systems, the leak will be identified, repaired/replaced, and retested to achieve passing tests. If any field density and moisture test results are outside of acceptable ranges, the areas will be reworked and retested to achieve passing tests. Unacceptable subbase material under manholes and underground piping will be removed and replaced with acceptable material. Any malfunctioning electrical or mechanical equipment will be replaced.

11.4 REFERENCE DOCUMENTS

- Technical Specification 02226 - Drainage Layers (Attachment B).
- Technical Specification 02610 - Underground Piping (Attachment B).
- Technical Specification 02733 - Polyethyle (PE) Manholes (Attachment B).
- Technical Specification 02775 - Geonet Geocomposite (Attachment B).
- Technical Specification 16000 - Electrical Requirements (Attachment B).
- Technical Specification 16900 - Instrumentation and Control Systems (Attachment B).
- Table 1C (Attachment A).
- Drawings: No. 8, 25-31.

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12.0 STORM WATER MANAGEMENT SYSTEM

The storm water management system consists of the following components:

- Storm water conveyance system, including:
  ~~Gravity drain header pipe~~ Catch basins and associated culverts
  - ~~Manholes~~
  - ~~Discharge piping~~ Drainage ditches
  - Emergency overflow discharge piping

- ~~Infiltration Basins~~ Detention ponds

12.1 OBSERVATION AND INSPECTION

Observation and inspection of the storm water management system construction will be performed by the CQA Engineer and will include the following:

- Observe installation of the storm water collection system ~~manholes~~ catch basins and associated culverts.
- Observe installation of the storm water gravity drain ~~header piping, and discharge piping to infiltration basins.~~ surface water drainage ditches and temporary culverts. Includes pipe inverts and location information.

~~Observe installation of the infiltration basin emergency overflow piping, including pipe inverts and location information.~~

- Observe and document excavations and backfill of pipe trenches, and catch basin ~~manhole~~ excavations, including restoration of any CAMU surface areas disturbed during construction.
- Observe installation/excavation of the ~~infiltration basins~~ detention ponds.
- Survey pertinent system inverts and elevations.
- Maintain daily field notes and testing records regarding project construction.
- Provide photographic documentation of major construction activities.

12.2 CONSTRUCTION TESTING

In-field testing will be performed to document that installation and materials used are in conformance with the design drawings and specifications. The Earthwork Contractor is responsible for selecting materials and components that meet project requirements. The Earthwork Contractor will submit manufacturers' information regarding selected materials for approval prior to installation. Specific testing and sampling activities for the Storm Water Management System are discussed below. In field and laboratory testing will be performed at the frequency shown in Table 1I (Attachment A) of this CQAP.

12.2.1 ~~Manholes~~ Catch Basins

The storm water management system catch basins ~~manholes (SM01 through SM07~~ CB1 through CB 8) ~~are~~ may be constructed of pre-cast concrete or polyethylene pipe. Construction will be documented by the CQA Engineer. Refer to Drawings ~~D23 and D24~~ D22 of the COLDR for ~~manhole~~ catch basin details.

12.2.2 Conveyance Piping

The buried conveyance piping includes ~~pipe systems including~~ the CMP discharge piping from the catch basins and temporary and permanent culverts. ~~the header pipes (18 to 24 in.ch diameter PE), discharge pipes (24 and 30 in.ch diameter concrete), and emergency overflow pipes (24 in.ch diameter corrugated metal pipe (CMP)) will be installed by the Earthwork Contractor.~~ All underground piping associated with the storm water management system will drain by gravity. Construction will be documented by the CQA Engineer. Refer to Drawings D10 and D22 ~~D23 and D24~~ of the COLDR for the header pipe locations and details, discharge pipe locations and details, and emergency overflow pipe locations and details. The location and elevations of the pipe systems, including inverts and junctions will be located by survey.

12.2.3 Detention Ponds ~~Infiltration Basins~~

The ~~infiltration basins~~ detention ponds will be excavated to grades indicated on Drawing D7 of the COLDR. Construction will be documented by the CQA Engineer. Grades will be verified by survey.

12.3 FAILING TESTS OR MATERIALS

Any unacceptable materials will be replaced.

12.4 REFERENCE DOCUMENTS

- Technical Specification 02270 - SWPE Protection and Erosion Control (Attachment B).
- Technical Specification 02720 - Storm Drainage Structures and Corrugated Pipe (Attachment B).
-
-
- Drawings: No. D10 and D22

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13.0 INSPECTION ACTIVITIES

13.1 PRECONSTRUCTION MEETING

A preconstruction meeting will be held at the CAMU site prior to beginning construction. The preconstruction meeting must be attended by the representatives of the CAMU Owner, the Engineer, the Earthwork Contractor, the Geosynthetic Contractor, the CQA Engineer, IDEM, and USEPA. This CQAP will be reviewed and the responsibility of each party will be reviewed and clearly understood. The meeting will be documented by the CQA Engineer and minutes will be transmitted to all participants.

13.2 PREFINAL INSPECTION

As the project is nearing completion, a prefinal inspection meeting will be held at the CAMU site. The prefinal inspection will be attended by the representatives of the CAMU Owner, the Engineer, the Earthwork Contractor, the Geosynthetic Contractor, the CQA Engineer, IDEM, and USEPA. The prefinal inspection will consist of a walk-through inspection of the entire CAMU site. The prefinal inspection will determine whether the project is being completed consistent with the contract documents. Any outstanding construction items noted during the prefinal inspection will be recorded. A prefinal inspection report will outline the outstanding construction items, actions required to resolve items, completion dates for these items, and the date for the final inspection.

13.3 FINAL INSPECTION

Upon completion of any outstanding construction items, a final inspection meeting will be held at the CAMU site. The final inspection must be attended by the representatives of the CAMU Owner, the Engineer, the CQA Engineer, IDEM, and USEPA. The final inspection will consist of a walk-through inspection of the project site. The prefinal inspection report will be used as a checklist and will focus on the outstanding construction items.

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14.0 DOCUMENTATION

Construction of the dewatering system (including the vertical barrier wall), site security (fence), CAMU excavation and berms, on-site roads, CAMU liner (and associated protection), leak detection/leachate collection systems, and storm water management system will be documented in accordance with the plans and specifications and this CQAP. The CQA Engineer must document that requirements of this CQAP have been addressed and satisfied.

The CQA Engineer must provide signed daily field reports, data sheets, and checklists to verify that monitoring activities have been carried out. The CQA Engineer must maintain at the job site a complete file of all documents that comprise or support this CQAP, including plans and specifications, checklists, test procedures, daily logs, and other pertinent documents.

Original documents will be stored by the CQA Engineer.

14.1 DAILY REPORTS

Daily field reports will be prepared by the CQA Engineer to document the activities performed on-site. Daily field reports must include:

- Daily temperature extremes (i.e., maximum and minimum).
- Daily cloud cover broken into A.M. and P.M.
- Observation and testing data sheets
- Daily precipitation.
- Discussions between the representatives of the Contractor, the CQA Engineer, and the CAMU Owner
- Documentation of construction problems and resolutions

14.1.1 Observation and Testing Data Sheets

Observation and testing data sheets will be prepared daily for each construction activity observed. At a minimum, these data sheets must include the following information:

- An identifying sheet number for cross-referencing and document control.

- CQA Engineer shall define a unique numbering system for individual components of the liner system (i.e., S = Secondary, P = Primary, LC = Leachate Collection, etc.). Numbering system will be utilized for the term of the project with any modifications to the system being downloaded in the CQA Engineer Daily Report.

- Date, project name, location, and other project identification information.

~~Documentation of weather conditions~~

  - Reduced-scale site plan showing all current work areas and test locations
  - Descriptions and locations of ongoing construction
  - Equipment and personnel in each work area, including subcontractors
  - Descriptions and specific locations of areas, or units, of work being tested and/or observed and documented (identified by lift and location)

- Initials of individual performing test (i.e., Contractor or CQA Consultant).
- Locations where tests and samples were taken
- Summary of test results
- Calibrations or recalibrations of test equipment, and actions taken as a result of calibration
- Off-site materials received, including quality verification documentation
- Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality
- CQA Technician initials.
- Signature of CQA Engineer

Photographic reporting data sheets, where used, must be cross-referenced with Observation and Testing Data Sheets and/or Construction Problem and Resolution Data Sheets. The photographs will serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints. Negatives will be stored in a separate file.

See Attachment C for typical CQA Observation Logs and required information.

14.1.2 Discussions Between Earthwork Contractor, Geosynthetic Contractor, and CQA Engineer

A memorandum will be prepared each day summarizing discussions between the representative of the CQA Engineer, the Earthwork Contractor and the Geosynthetic Contractor. At a minimum, the memorandum will include the following information:

- Date, project name, location, and other project-related identification
- Name of parties involved in discussion
- Relevant subject matter or issues
- Activities planned
- Constraints and/or suggestions
- Schedule impacts
- Signature of the CQA Engineer

14.1.3 Construction Problems and Resolutions

Sheets describing special construction situations will be cross-referenced with specific Observation and Testing Data Sheets, and must include the following information:

- An identifying sheet number for cross-referencing and document control
- A detailed description of the situation or deficiency
- The location and probable cause of the situation or deficiency
- How and when the situation or deficiency was found or located
- Documentation of the response to the situation or deficiency
- Final results of any response
- Any measures taken to prevent a similar situation from occurring in the future
- Signature of the CQA Engineer

The Engineer must be made aware of any significant reoccurring activities that do not conform with the design and specifications.

14.2 FIELD TESTING REPORTS

Records of field and laboratory testing performed on components of the ~~dewatering system (including the vertical barrier wall),~~ site fence, CAMU excavation and berms, on-site roads, CAMU liner (and associated protection), leak detection/leachate collection systems, and storm water management system must be collated by the CQA Engineer. A summary list of test results will be prepared by the CQA Engineer on a continual basis.

14.3 PROGRESS REPORTS

The CAMU Owner must submit signed monthly progress reports to USEPA during the construction phase. These progress reports must include as a minimum (and as appropriate):

- A description and estimate of the percentage of the CAMU completed
- Summary of findings
- Summary of changes made in the CAMU during the reporting period
- Summaries of contacts with representatives of the local community, public interest groups, or State government during the reporting period
- Summary of problems or potential problems encountered during the reporting period
- Actions being taken to address these problems
- Changes in key personnel during the reporting period
- Projected work for the next reporting period
- Copies of daily reports, inspection reports, and laboratory/monitoring data (if available)
- Comparisons of working schedule to project schedule
- Summaries of conference calls and meetings held during the reporting period between the CAMU Owner and USEPA

14.4 INSPECTION REPORTS

Inspection reports will be completed after each of the required inspections have occurred to document the inspections. Documentation of the inspections will be prepared by the CQA Engineer and will be issued to all participants in the inspection meeting.

14.5 AS-BUILT DRAWINGS

As-built drawings of the dewatering system (including the vertical barrier wall), site fence, CAMU excavation and berms, on-site roads, CAMU liner (and associated protection), leak detection/leachate collection systems, and storm water management system will be prepared by the CQA Engineer and included in the Construction Completion Report. The information will be presented on scale drawings both in plan view and in cross-section. At a minimum, the drawings will include the following:

~~Record locations of barrier wall~~
~~Record location of dewatering wells~~

- Record location ~~and inverts of the dewatering system, leak detection and~~of leachate collection systems.
- Record by survey or specific coordinate system geomembrane panel layout, seam identifications, repairs, and location of all destructive seam test samples.

- Record grades of the finished surface.
- Location of field tests and samples obtained for laboratory testing.
- Cross sections.
- Plan and Profiles.
- Details.

14.6 CONSTRUCTION COMPLETION REPORT

Following the final inspection, a Construction Completion Report will be prepared by the CQA Engineer and submitted to the CAMU Owner for submittal to USEPA. The Construction Completion Report will confirm that the work has been performed in substantial compliance with the design plans and specifications. The Construction Completion Report will include the following:

- Summary of construction activities.
- Observation and Testing Data Sheets, including sampling locations.
- Construction problems and solutions.
- Photographic documentation.
- Changes from design and material specifications.

14.7 FINAL STORAGE OF RECORDS

Final records of the construction of the CAMU will be maintained in the CQA Engineer's files. Copies of reports and other submittals will be retained by the CAMU Owner and USEPA.

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Table 3-2
CAMU Volume and Earth Quantities
Construction/Operation Level Design Report
GCR-CAMU
U.S. Steel

	Unit 1	Unit 2	TOTAL
Property Acreage (acres)			**59.9**
Area of Waste Placement (acres)	10.60	26.98	**37.58**
Area of Freeboard/Water Pool Interface (acres)	10.30	26.61	**36.91**
Area of Water Pool/Spoils Interface (acres)	9.95	26.18	**36.13**
Total Volume (cy) (inside edge of berm)	420,400	1,213,000	**1,633,400**
Volume of Freeboard (3.5 ft) (cy)	58,200	149,700	**207,900**
Volume of Water Pool (4 ft) (cy)	65,300	170,300	**235,600**
Volume of Drainage Blanket (2 ft) (cy)	20,600	69,400	**90,000**
Capacity for Dredge Solids (cy)	276,300	823,600	**1,099,900**
Calculated Needed Dredge Solids Capacity (Table 3-1) (cy)	*177,100*	*973,500*	***1,150,600***
Proposed Dredge Filling Rate (gpm)			
Maximum	3,000	7,500	
Average	2,700	6,250	
Total Volume to Cut (cy)			**227,000**
Total Volume to Fill (cy)			**351,000**
Net Fill (cy) (additional general fill required)			**124,000**
Volume of Existing Dredge Spoils (cy)			**201,000**

Notes:

1. Volume estimates are rounded to the nearest hundred cubic yard.
2. Total Volume of Units 1 and 2 were computer calculated by the Inroads program with Microstation.
3. Volume of freeboard and water pool were calculated by the Inroads program with Microstation.
4. Volume of drainage blanket were calculated based on area.
5. Total cut/fill volumes were computer calculated by the Inroads program with Microstation.
6. Volume of existing dredge spoils were calculated based on isopach map in the PLDR.
7. Material required for the granular drainage blanket will be obtained from an off-site source.
8. Material required for topsoil will be obtained from an off-site source.
9. Assumes 1H:1V interior sidewalls above elevation 600, and 2.5H:1V below elevation 600.
10. Assumes 1H:1V exterior sidewalls.
11. Assumes setbacks from surveyed utilities.
12. Minimum base elevation is 586.
13. Perimeter berms at elevation 620.

Attachment A

ATTACHMENT A

CONSTRUCTION TESTING AND FREQUENCY TABLES

Table 1A
CAMU Construction Testing and Frequency
Excavation and Site Preparation

Property	Qualifier	Frequency	Specified Value	Test Method(s)
Subbase Fill / Base-Grade Preparation				
Survey-Base Grade	minimum	100-ft grid and major grade breaks	0 to –2 inches	Technical Specification 02220 Section 3.6
Berms/Other General Fill				
Field Dry Density and Moisture Content	minimum	Every 100-lf per 1-ft thickness	90% of maximum dry density determined by the Modified Proctor method	ASTM D2922 and D3017 (nuclear method)
Moisture-Density Relationship	minimum	1 per 5,000 cy		Modified Proctor ASTM D1557
Survey-Grade and Thickness	minimum	100-lf and major grade breaks	0 to +3 inches	Technical Specification 02220 Section 3.6
Dredge Spoil/Lime Kiln Amended Soils				
Field Dry Density and Moisture Content	minimum	Every 100-lf per 1-ft thickness	90% of maximum dry density determined by the Modified Proctor method	ASTM D2922 and D3017 (nuclear method)
Moisture-Density Relationship	minimum	1 per 5,000 cy		Modified Proctor ASTM D1557
Unconfined Compressive Strength (dredge spoil/lime kiln amended soils)	minimum	Minimum 3 inplace samples or upon changes in mix preparation and placement	8 day cured strength of 4,600 psf	ASTM D2166
Clay Backfill (Interior and Perimeter Access Roads)				
Field Dry Density and Moisture Content	minimum	Every 100-lf per 1-ft thickness	90% of maximum dry density determined by the Modified Proctor method	ASTM D2922 and D3017 (nuclear method)
Atterberg Limits	minimum	1 per 1,000 cy	Ave LL = 25 Min LL = 20 Ave PI = 12 Min PI = 10	ASTM D4318
Grain Size	minimum	1 per 1,000 cy	P200 $\geq$ 50%	ASTM D422
Moisture-Density Relationship	minimum	1 per 5,000 cy		Modified Proctor ASTM D1557
Survey-Grade and Thickness	minimum	100-lf and major grade breaks	0 to 2 inches	Technical Specification 02223 Section 3.3 and 3.4

Table 1B
CAMU Construction Testing and Frequency
Road Construction

Property	Qualifier	Frequency	Specified Value	Test Method(s)
Field Dry Density and Moisture Content	minimum	Every 100-lf per 1-ft thickness	90% of maximum dry density determined by the Modified Proctor method	ASTM D2922 and D3017 (nuclear method)
Moisture-Density Relationship	minimum	Every 5,000 cy		Modified Proctor ASTM D1557
Grain size distribution	minimum	Every 5,000 cy		ASTM D422
Survey subbase, base, and final grades	minimum	Every 100-lf	0 to +3 inches	Technical Specification 0220 Section 3.6

Table 1C
CAMU Construction Testing and Frequency
Leachate Collection System / Leak Detection System

Property		Qualifier	Frequency	Specified Value	Test Method(s)
Pipe Bedding Material					
Grain size distribution		minimum	Every 500 lf	ASTM D2321 Class IA, IB, II	ASTM D422
Conveyance Piping					
Pressure Test	Manholes, collection manholes, header risers, cleanouts	minimum	Entire pipe length/structure	3 psi for 30 minutes with 0 psi loss.	Technical Specification 02610 Section 3.4
	Leachate Forcemain	minimum		75 psi for 30 minutes with 0 psi loss.	
Survey		minimum	Every 100 lf, invert elevations, and all pipe fittings, etc.	0 to +0.10 feet	Technical Specification 02610 Section 3.3.A
Collection Piping					
Survey		minimum	Every 100 lf, invert elevations, and all pipe fittings, etc.	0 to +0.10 feet	Technical Specification 02610 Section 3.3.A
Trench Backfill					
Grain Size Distribution		minimum	Every 100 lf per 1-ft thickness		ASTM D422
Granular Drainage Layer (Leachate Collection system Only)					
Grain size distribution		minimum	1 per 5,000 cy	INDOT #12 and INDOT #24	ASTM D422
Hydraulic Conductivity		minimum	1 per 5,000 cy	$1x10^{-2}$ cm/sec	ASTM D2434
Survey		minimum	100-ft grid including major grade breaks	0 to +2 inches	Technical Specification 02226 Section 3.2.A
Leachate Collection Sumps					
24-hour Leak Detection Test		minimum	Each sump		
Survey		minimum	Each sump	0 to –2 inches	Technical Specification 02220 Section 3.6.C.
Manholes (Collection and Conveyance)					
Survey		minimum	All inverts	0 to +0.10 feet	Technical Specification 02610 Section 3.3.A

Table 1D
CAMU Construction Testing and Frequency
Smooth and Textured Geomembrane

Property		Qualifier	Frequency	Specified Value	Test Method(s)
Thickness		minimum	Each Roll	54 mils	ASTM D1593 Para. 8.1.3 or ASTM D751
		nominal		60 mils	
Specific Gravity (density)		minimum	1 per 100,000 sf per material type	0.93 g/cc	ASTM D792 or D1505
Melt Index (resin)		maximum	1 per 100,000 sf per material type	1 g/10 minutes	ASTM D1238
Tensile Properties (Machine and Cross Direction)					
1. Yield Strength		minimum	1 per 100,000 sf per material type	126 lbs./inch width	ASTM D638
2A. Break Strength (smooth geomembrane)				228 lbs./inch width	
2B. Break Strength (textured geomembrane)				90 lbs./inch width	
2. Elongation at Yield				12%	
4A. Elongation at Break (smooth geomembrane)				700%	
4B. Elongation at Break (textured geomembrane)				100%	
Tear Resistance		minimum	1 per 100,000 sf per material type	42 lbs.	ASTM D1004, Die C
Puncture Resistance		minimum	1 per 100,000 sf per material type	78 lbs.	FTM STD 101C
Environmental Stress Cracking Resistance		minimum	Each Resin Batch	500 hours	ASTM D1693 (modified in NSF Appendix A, Condition C, 100^0 C)
Field Testing and Sampling					
Trial Weld Seams[1]	Peel Adhesion (smooth)	minimum	Start of seaming period, every 4 hours, equipment repairs, and wide changes in geomembrane temperature.	75 lbs./inch width and FTB[2]	ASTM D4437
	Peel Adhesion (textured)			63 lbs./inch width and FTB[2]	
	Bonded Seam Strength (Shear)			115 lbs./inch width and FTB[2]	
Non-Destructive Seam Testing	Air Pressure	minimum	Entire Length of Each Seam	27 psi minimum for 5 minutes with less than 3 psi pressure loss	GRI-GM6
	Vacuum			4-8 psi for 10 seconds, with no visible bubbles	ASTM D5641
Destructive Seam Tests		minimum	1 per 500 lf of seam	Same seam strength, FTB, and seam separation as trial welds. A minimum 5 bone samples for both peel and shear (alternatively collected across sample). A minimum 4 of 5 bones must pass seam strength, FTB, and separation requirements.	ASTM D4437

Notes:

1. Field testing of trial welds shall be done on a minimum 2 "bones" in peel from each end of the trial weld sample and 1 "bone" in shear randomly selected across the trial weld sample. On double-tracked fusion welds, both side of the seam shall be tested. An acceptable trial weld is obtained when all "bones" meet seam strength, FTB, and seam separation requirements. Failed trial welds shall be followed by two passing trial weld samples.
2. For fusion welded seams (single or double-tracked welds), no more than 10% of seam width shall separate at any point. For extrusion welded seams, no more than 1/8-inch seam separation from seam edge at any point

Table 1E
CAMU Construction Testing and Frequency
Geocomposite

Property	Qualifier	Frequency	Specified Value	Test Method(s)
Geocomposite (Completed Product)				
Transmissivity [1]	minimum	2 tests	1.24×10^{-3} m^2/s	ASTM 4716
[1] Tests to be performed with site specific material at 6,000 psf normal loading at 0.01 gradient				

Table 1F
CAMU Construction Testing and Frequency
Geosynthetic Clay Liner (GCL)

Property	Qualifier	Frequency	Specified Value	Test Method(s)
Bentonite mass/area	minimum	1 per 100,000 sf	0.75 psf (oven dried)	ASTM D5993
Tensile Strength	minimum	1 per 100,000 sf	150 lbs.	ASTM D4632
Peel Strength	minimum	1 per 40,000 sf	15 lbs.	ASTM D4632

Table 1G
CAMU Construction Testing and Frequency
Geotextile (Primary Geomembrane Cushion Layer)

Property	Qualifier	Frequency	Specified Value	Test Method(s)
Grab Strength	marv	1 per 100,000 sf or 1 per lot whichever is least.	270 lbs.	ASTM D4632
Wide-Width Tensile Strength	marv		125 ppi	ASTM D4595
Trapezoidal Tear	marv		75 lbs.	ASTM D4533
Puncture Strength	marv		80 lbs.	ASTM D4833

Table 1H
CAMU Construction Testing and Frequency
Anchor Trenches

Property	Qualifier	Frequency	Specified Value	Test Method(s)
Field Dry Density And Moisture Content	minimum	1 per 100 lf of trench per 1-ft lift.	90% of maximum dry density determined by Modified Proctor (ASTM D1557)	ASTM D2922 and D3017 (nuclear method)
Moisture-Density Relationship	minimum	1 per 1,000 cy		ASTM D1557 (Modified Proctor)
Survey	minimum	Every 500 lf	0 to +2 inches	Technical Specifications 02220 Section 3.6.A.

Table 1I
CAMU Construction Testing and Frequency
Storm Water Management System

Property	Qualifier	Frequency	Specified Value	Test Method(s)
Survey	minimum	All pipe and structure inverts, general surface survey	Pipe inverts: +/-2 inches Berms/swales: 0 to +3 inches	Technical Specification 02720 Section 3 Technical Specifications 02220 Section 3.6.B.

Table 1J
CAMU Construction Testing and Frequency
Interface Friction Angle Testing

	Interface	Normal Stress Loads	Specified Value	Test Method(s)
Sideslope Liner	GCL to Insitu soil or backfill soils	500; 2,000; 4,000; and 8,000 psf with wet interfaces	13 degrees[1]	ASTM 5321
	GCL to Textured HDPE Geomembrane		21 degrees[1]	
	Textured HDPE Geomembrane to Geocomposite		21 degrees[1]	

Notes:

1. All friction angles are residual values.

Table _____
CAMU Construction Testing and Frequency

Property	Qualifier	Frequency	Specified Value	Test Method(s)